A TREATISE

ON

SURGERY

BY

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TO MY WIFE

WHOSE DEVOTION HAS ENABLED ME TO
WRITE THIS BOOK

PREFACE

In presenting a new work on Surgery the author has endeavored to bring together the most recent and improved methods of surgical practice, and, with the aid of numerous cross-references, to arrange these in a form readily available to the student and practitioner. As a necessary preliminary to this, the so-called art of surgery, the effort has been made to set forth the fundamental principles underlying what is known as the science of surgery in both an interesting and an instructive manner.

The study of inflammation from the surgical viewpoint is based on the tissue changes that follow the infliction of wounds. Contrary to the usual custom the subject of Surgical Bacteriology is introduced in connection with the etiology of inflammation, in which it is an important factor.

The grouping of the topics differs somewhat from the arrangement usually employed, as will be seen by reference to the table of contents. It is believed that the study of the subject will be facilitated by this method of classification.

The section on Laboratory Aids in Surgical Diagnosis and Prognosis it is believed will be specially valuable, owing to the increasing interest in hematology, urinology, and kindred subjects.

The practical part of the work comprises a separate consideration of the injuries and diseases of each region. This, the anatomic method, it is hoped will appeal to the surgical clinician, particularly with reference to diagnosis.

The section on Surgical Bacteriology is the work of Dr. A. T. Bristow, and the section on Laboratory Aids in Surgical Diagnosis and Prognosis that of Dr. F. E. Sondern. I wish to express my indebtedness to these gentlemen for their valuable contributions.

The aid rendered by Dr. W. C. Wood in connection with the section on Injuries and Diseases of the Bones and Joints, by Dr. Russell S. Fowler in the preparation of the section on Bandaging and other portions of the text, by Dr. G. E. Buist in connection with the section on Surgical Anesthesia, and by Dr. T. B. Spence is gratefully acknowledged.

My thanks are due also to my clinical assistants, Dr. J. E. Jennings, Dr. C. F. Buckley, and Dr. Carl Fulda, for efficient help in the work, and to my hospital internes for the compilation of clinical material from the records of my hospital services.

The final preparation of the manuscript as well as the supervision of the passage of the sheets through the press is the work of Miss Annie T. Keyser, Editor and Proof Reader of Question Papers, New York State Education Department, to whose faithful, painstaking, and efficient coöperation in bringing out the book I am greatly indebted.

The illustrations are the work of Mr. F. A. Deck, to whose skill is due the aid that these furnish in the elucidation of the text.

Finally, I wish to extend my acknowledgments to the publishers for their unremitting endeavors to make the work represent the highest ideal of the bookmaker's art.

George Ryerson Fowler.

Brooklyn, New York City
January, 1906.

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A TREATISE ON SURGERY

PART I

GENERAL SURGERY

SECTION I

INFLAMMATION

Inflammation, as viewed from the surgical standpoint, is that series of changes in the tissues which takes place as the result of injury plus infection. In the absence of infection and during the repair of an injury, however, the processes concerned are histologically identical with those concerned in inflammation. But the differences in degree and extent are such as to stamp the one as a pathologic process and the other as a physiologic process. The study of the phenomena will therefore naturally commence with the injury itself.

.WOUNDS

A wound is the forced separation of any portion of the skin or mucous membrane so that the protective covering of the underlying tissues is destroyed and the latter exposed to the influence of the air and other extraneous matters.

Classification and Mechanism.—Wounds of the external surface of the body involving exposure of the subcutaneous connective tissue are divided, according to the condition of the edge of the wound, into those possessing (1) well-defined edges; (2) lacerated solutions of continuity of the surface; (3) contused breaches of tissue.

Wounds with well-defined and sharp edges are subdivided into **incised** and **punctured** wounds. **Lacerated wounds** occur where there is excessive tension on the skin by the application of a dragging force, or where the tissues are forced against some unyielding part, as, for instance, the skull.

Contused wounds are caused by contact of the body with an object having a broad surface, or by falls upon hard angular surfaces. Wounds resulting from the blow of a club, or from the entrance into the body of some missile (gunshot wounds), are familiar examples of contused wounds.

In addition to these, wounds are spoken of as **penetrating** when the foreign body enters a cavity of the body without emerging; as **perforating** when

the foreign body enters and emerges. If some specific poison has been carried into the wound and has infected it, it is then spoken of as a **poisoned wound.**

Wounds are likewise said to be **septic** or **aseptic,** according as they have been infected or not with those organisms which excite putrefaction or other disorganization of tissue. Destruction of tissue to a greater or lesser extent characterizes all wounds.

Symptoms.—A symptom common to all wounds is **separation** and gaping of its edges. This is caused by the presence of elastic fibers in the connective tissue and cutis, and emphasizes the elasticity characteristic of the uninjured skin. The degree of gaping depends on the number and direction of the elastic fibers, as well as on the depth of the wound. If the wound separates the tissues in a direction parallel to that of the elastic fibers, the gaping will be less than when these are separated in a transverse direction. Deep wounds gape more than superficial ones.

The **hemorrhage** which accompanies a wound depends on the depth, length, and breadth of the wound, as well as on the size and condition of the divided blood-vessels. As a rule, this symptom is less marked in contused and lacerated wounds than in those with clean-cut and sharply defined edges.

The symptom of **pain** is usually an immediate accompaniment of a wound, and results from the injury and irritation of the numerous fibers of sensory nerves in the injured tissues. It is of a sharp, burning character and radiates along the nerve-trunk or in the area of its distribution. The more rapidly and thoroughly the nerve-fibers are divided, the less, as a rule, is the pain. It may happen that no pain whatever is experienced, owing to the rapidity with which the wound is inflicted, or to mental excitement at the time of the injury. In clean incised wounds the wounded person may not be aware that he is injured until his attention is attracted by the presence of blood. Contused wounds are the most painful of injuries. Individual temperament also may modify the amount of pain. Courageous persons and those in a furious rage, on the one hand, and those exercising a quiet self-control, on the other, suffer the least, for these conditions act as restraining influences on the sensory cortical centers.

Healing by Primary Intention, i.e., without Suppuration.—Wounds with sharply defined edges and but slight separation may heal in a relatively short time, no essential change being discoverable in the wound and its surroundings. A very narrow blood-coagulum fills the interspace and causes agglutination of its edges, while the upper layers of this coagulum projecting just beyond the edges become dried and form a thin line or scab, hermetically sealing the wound. In the earlier stage of this reparative process the wound may be reopened by very slight violence, but as organization takes place in the thin cement of blood-clot, union becomes firmer, until finally the narrow surface scab falls off, leaving a bluish or purple furrow covered with new and tender epidermis—the cicatrix. The period of time occupied by the healing process varies with the degree of separation of the edges of the original wound. Small incised and punctured wounds that have not been exposed to irritating or septic influences may heal in the course of twenty-four hours. As a rule, however, from five to seven days are required before the falling of the crust announces the completion of the healing process.

Even considerable losses of substance in the skin, particularly if extending only to the rete Malpighii, may be completely repaired in a very short time;

the hemorrhage being very slight in these cases, the effused blood dries rapidly, and, under the protection of the crust thus formed, cicatrization is soon complete.

Healing by Secondary Intention, i. e., with Suppuration.—In a widely gaping wound the extent of the injury and the size of the coagulum may prevent rapid drying. In the absence of preventive measures there are present all the conditions favorable to the implantation and reproduction of septic organisms, namely, (1) organic tissues deprived of their protecting cuticle; (2) a favorable temperature (blood-heat); (3) moisture. In trivial incised wounds the surface of the coagulum dries quickly, and septic organisms are thus deprived of that moisture which is absolutely essential to their growth; but in the case of large gaping wounds desiccation cannot take place rapidly; as a result bacteria quickly multiply therein, and decay and disorganization of tissue take the place of repair. Under these circumstances in the course of twenty-four hours the wound is covered with a semiliquid, foul-smelling layer of broken-down tissue swarming with the organisms of putrefaction. Peculiar changes due to a local sepsis or infection occur also in the neighborhood of the wound. A more or less broad zone of redness appears about the edges, together with increased heat and subsequent induration, and the patient complains of pain and a feeling of tension in the surrounding tissues. These symptoms increase as putrefaction of the coagulum progresses. In some contused wounds a foul-smelling, semiliquid mass exudes from beneath the lacerated edges, mingled with the debris of broken-down tissue. If improvement occurs, a yellowish-white and creamlike secretion makes its appearance over the edges of the wound about the fifth day, and the "laudable pus" of the older surgery is present. With the cessation of the so-called ichorous discharge the wound enters on the stage of suppuration.

With the advent of suppuration there is a diminution of the redness, heat, swelling, and pain which are the classic symptoms of an inflammatory process. The length of time covered by the stages of suppuration varies with the depth of the wound, the extent of the laceration of its edges and the contusion of surrounding parts. In an uncomplicated lacerated wound, from about the seventh day there is observed a mass of material of pinkish hue which forms beneath the layer of pus and rises from the depths of the wound. This consists of small papillae which continue to rise higher and higher until they fill in the entire wound cavity, so that its surface presents a granular appearance. The wound is then said to be "granulating," and the papillae are called "granulation tissue." The presence of granulations constitutes another stage in the process of repair.

The parts surrounding the wound at this time return nearly or quite to their normal condition. Redness and heat disappear, and tenderness, with perhaps some induration, alone remains to indicate that the reparative process is still going on in the depths of the wound. As the cavity of the wound becomes filled with granulation tissue the latter, which up to this time has been more or less easily injured and has bled at the slightest touch, becomes to some extent solidified, loses its bright pink color, and grows pale. At the same time a process of shrinkage goes on, and in a corresponding degree the cavity of the wound markedly diminishes.

When the granulating surface is level with the surrounding surfaces, a narrow strip of new epidermis begins to grow around the edges of the wound, and increases from without inward. One zone after another, growing concentrically, is added to the new tissue until, when they meet in the middle, the new epidermis completely covers in the granulating surface and cicatrization is accomplished.

The two processes of healing thus briefly described have been recognized for years, but it was not until John Hunter (1793) pursued his classic studies on the subject that these processes were fully recognized and distinguished as **healing** by **primary** and by **secondary intention.**

Healing by first intention seems almost a physiologic process, inasmuch as it is the simplest and most direct method of repairing tissues lost or destroyed. In some of its stages it seems to be akin to the processes of restitution of epithelial tissues constantly going on as normal metamorphosis, if indeed it is not entirely identical with them.

In the second method of repair, healing by second intention, the reproduction of tissue in connection with suppuration is marked by the presence of true inflammatory conditions, the essential and characteristic symptoms of which have been known since the days of Galen, namely, (1) **redness (rubor)**; (2) **local heat (calor)**; (3) **swelling (tumor)**; (4) **pain (dolor).** To these is to be added (5) **interference with the function of the part (functio laesa).**

Histology of the Healing Process.—Such a thing as immediate union after the infliction of a wound does not occur, if by this is meant the direct adhesion of the histologic elements of the parts, without further reparative effort. Trabeculae form in the exuded fibrin, making up a fine network from which processes are sent out into the open blood-vessels and into the clefts or spaces between the tissues. In the cavity of the wound itself, however, there will be found, besides blood-corpuscles, small portions of necrotic tissue and coagulated fibrin. The blood-corpuscles are partly unchanged. Some, however, have assumed a star-shaped appearance, while others are swollen and pale in color. The passage of the trabeculae of the coagulum into the mouths of the open blood-vessels leads to coagulation in the neighboring capillaries. In from twenty-four to forty-eight hours the red blood-corpuscles have almost entirely disappeared. Those which remain have lost their color and have become diaphanous or finely granulated. The spaces now found in the network mark the site of former blood-corpuscles which have been destroyed. Simultaneously with the disappearance of the red blood-corpuscles, the so-called cells of new formation make their appearance. These are small round-cells with a clear nucleus, which in size and general appearance resemble the young cells of connective tissue as well as the colorless blood-corpuscles themselves. These gradually fill up the gap in the wounded structures, and in addition are crowded into the neighboring perivascular spaces. About the fourth day blood-vessels in small loops pass from the edges of the wound, and meeting in the center anastomose or unite in the new cellular mass (Julian Arnold). These vessels are the result of a process of proliferation. A slight granular thickening on the wall of a capillary marks the point whence a new vessel is about to bud. This projects in a somewhat triangular shape, and is the so-called protoplasmic proliferation. The projection develops into a fine cord with a threadlike termination, becomes hollow at the base, and

blood enters it from the parent vessel. By the union of these protoplasmic cords an arch-shaped connection is established between two capillaries, constituting the so-called protoplasmic arch. In the beginning this contains blood only in the hollow base, but a process of canalization takes place in the intermediate portion and later complete communication is established. These protoplasmic arches are at first homogeneous, but a nucleated structure subsequently replaces the homogeneous connection, and they become lined with endothelium. Later, by a process of cleavage new cellular elements develop and new capillary vessels are formed from the condensed cellular bodies. This primary cellular layer is enlarged from within by the adjacent round-cells of new formation (formative cells of Marchand), which latter form the adventitia of the new vessels.

Thiersch carefully injected tissues undergoing reparative processes and microscopically examined sections of the same. He believed that spaces existed between the connective-tissue new-formation cells and that the injected fluid passed into these from the blood-vessels; on the basis of these experiments he assumed that there was a system of intercellular canals communicating directly with the vessels whose function was to supply nutriment to the parts until new blood-vessels were formed. It is extremely difficult at the present time to decide whether such a system of plasma canals really exists or whether Thiersch's injections penetrated simply into the protoplasmic arches and the proliferations of the vessels of Arnold.

The formative round-cells which fill the wound soon begin to undergo transformation. The intercellular spaces increase, and between them there grows a framework, partly striped, partly granular, which in all probability originates in the cells themselves. At a still later stage of development the striped appearance of the intercellular substance becomes more clearly defined, eventually developing into fine fibers, between which are found spindle-cells, perhaps the remains of the masses of round-cells.

With the disappearance of the round-cells and the appearance of the newly formed fibers the new tissue closely resembles young connective tissue. As cicatrization goes on, the spindle-cells, as well as the round or formative cells, vanish, some undergoing granular degeneration and absorption while others are either taken up again by the circulation, or, after reaching a certain stage of development, destroyed by cell action in the process. The shelter of the epidermis is now needed to complete repair. On the surface of the built-up tissues a clot or crust consisting of broken-down blood-corpuscles, epithelial scales, and exudation forms, and beneath this new epithelium develops, which the rete Malpighii of the adjoining skin furnishes. Its cells are increased by nuclear segmentation, and these new cells arrange themselves along the young connective tissue until they meet and finally cover in the surface of the wound.

The histologic process which marks the healing of a wound by second intention (healing by suppuration) is essentially the same. Here also after a few hours the round-cells appear. When brought in contact with the putrid blood, they rapidly perish and mingle with the foul secretions of the wound. Microscopically at this time the discharge during the first three days consists of portions of fibrin, red blood-corpuscles in different stages of decomposition, granular detritus, bacteria, and, finally, of dead connective-tissue cells that undergo changes in quality and form the principal components of pus. From the

surface of the wound, however, while numerous connective-tissue cells are being thrown off, new ones are being supplied to take their places, until the lowest layer, being gradually supplied with blood-vessels, remains to form the young connective tissue. This, with its numerous loops of vessels, each surrounded by a growth of the same connective-tissue cells, appears as a surface of light and irregular nodules, the granulations. The discharge of pus gradually lessens. No disturbing influence interfering, the granulation tissue gradually fills up the cavity, and its size is diminished also by a general shrinkage of the whole mass. Finally, as the wound surface becomes level with the surrounding integument, cicatrization is completed by the renewal of the protective epidermis, as before described. As a rule, the new epidermis forms a narrow zone about the edges of the wound, but occasionally little islets spring up at varying distances from the margins themselves, to become the centers of successive zones of new epidermis. The latter may originate from the cells surrounding the sweat-glands and hair-follicles, which, passing as they do deeply into the cutis, may have escaped injury, even in wounds involving considerable loss of substance. Again, it may occur during changes in dressings, or in some other way, that epidermal cells may be sown over the granulation tissue, transplanted, as it were, from sound skin. It has likewise been suggested that a narrow epithelial strip may extend from the margin of the wound to the islets. However this may be, it is not at all probable that these epithelial cells are formed from the round-cells of the granulation tissue.

An additional division of the subject is made by some writers, the so-called **"healing by third intention."** In granulating wounds rendered aseptic and maintained so, direct union is said to take place, if, after the lapse of two or three days, or when the granulating process is well under way and there is but little or no secretion present, the granulating surfaces are brought into apposition. The histologic process, however, differs in nowise from the foregoing. Septic conditions are replaced by an aseptic state, and the gap to be filled is simply lessened by mechanical means.

The question of the **origin of the connective-tissue cells** during the healing process has received a great deal of attention. It was formerly supposed that the spindle-shaped corpuscles, the only cells then known to exist as connective-tissue cells, were the progenitors of the round-cells. The origin of this belief seems to be the observation previously made that in fetal connective tissue spindle-cells developed from the round-cells lying in large numbers in the matrix. In 1863 Recklinghausen, in the course of experiments on the corneas of rabbits and frogs, found, in addition to the so-called fixed corneal corpuscles, small round-cells which possessed the peculiar property of changing their form and position in a manner entirely independent of one another. They bore a striking resemblance to the round-cells of pus, as well as to the white blood-corpuscles. Cohnheim, in 1867, demonstrated the direct origin of the migrating cells from the blood. The mesentery of the frog was used for the experiment, and the white blood-corpuscles were observed to escape through the uninjured wall of the vessel into the perivascular connective-tissue spaces (diapedesis). Thoma (1878) succeeded in demonstrating in the exposed mesentery of the dog (1) the dilatation of the vessels and the retardation of the blood-current; (2) the adhesion of the white blood-corpuscles to the walls of the capillaries; (3) the passage of the corpuscles through the

walls of the vessels. The query as to whether all the pus present in a case of prolonged suppuration can be accounted for by Cohnheim's theory of diapedesis is an interesting one. There are to be accounted for, in addition, the round-cells, the newly formed blood-vessels, their walls first homogeneous and then nucleated, the young connective tissue, and the granulation structure. Do these all originate from the white blood-corpuscles? While the adversaries of the exclusive diapedesis theory asserted that corpuscles of connective tissue, as well as endothelial cells, underwent a contractile change of shape and division, Cohnheim and his followers combated this with the classic experiments with cinnabar. The blood of frogs was injected with cinnabar, the finely divided particles of which were readily absorbed by the white blood-corpuscles. This furnished a method of distinguishing them from other cell-elements for which they might be mistaken. The frog, after the injection, was injured, and at the site of the injury could be seen escaping the white blood-corpuscles inclosing the particles of cinnabar. The value of this experiment as conclusive proof of the theory of diapedesis is impaired, as is justly remarked by Recklinghausen, on account of the well-known fact that the particles of cinnabar may escape directly into the tissues from the blood-vessels of frogs so injected and impart their stain to cells formed outside the vessels.

Experimental research on animals and observations in man have thus far determined of inflammation as follows: That it consists in (1) *dilatation of blood-vessels;* (2) *increase in the permeability of the walls of the blood-vessels;* (3) *augmented supply of nutriment to the tissues;* (4) *migration of white blood-corpuscles through the vascular walls into the surrounding connective-tissue spaces.* In addition, there also probably occurs (5) *proliferation of pre-existing cells.* Finally, under certain circumstances *processes of degeneration and decomposition take place, resulting in more or less loss of tissue.*

This histologic definition of the process of inflammation corresponds throughout to the clinical picture. The local results of the morbid processes vary with their intensity and extent. In other words, the varieties of inflammation are due to differences in the factors thereof. In individual cases the four cardinal symptoms of Galen, redness, heat, swelling, and pain, do not coexist in the same degree.

The **redness** of the inflamed part is the consequence of the dilatation of the vessels, and results from a paralysis of the muscular coat. This is due to an immediate disturbance either of the cells in the muscle-fibers themselves, or of the vasomotor nerves supplying them. At the very outset this is the exclusive cause of the redness, but later on it is further due to the occurrence of a stasis in the capillaries which leads to local accumulation of red blood-corpuscles, and finally to a formation of new blood-vessels as well, provided the inflammation persists.

Increased heat in the inflamed part **is due to the increased amount of blood** which the dilated capillaries supply to the tissues; in addition, there are probably some chemic processes to be taken into account (such as increased oxidation), but to what extent it is difficult at present to decide.

The **swelling** of the inflamed tissue depends on the same causes, and, in addition, on an increase in nutritive material supplied by the escape of the white blood-corpuscles from the capillaries into the connective-tissue spaces, as well as on the proliferation of the connective-tissue cells themselves.

Pain felt at the seat of inflammation is to be referred to an irritation of the sensory nerves of the part and the amount of pressure exercised on them by the dilated blood-vessels and the products of inflammation. The varying character of the pain is caused in part by the varying force of the blood-current, in part by the occurrence of congestion in dependent parts, and to some extent by the resistance which the tissues offer to the increase of nutrient material and to the products of inflammation.

INFLAMMATION IN GENERAL

The reparative process already considered consists, first, of that in which the loss of the essential tissue elements is immediately replaced; second, of that in which the repair is accomplished by the slower and more tedious process of suppuration. In the first case the cellular material for repair is at once appropriated to its uses without waste, with the co-operation of the adjacent vessels and without disturbance of neighboring structures. In the second, the putrid decomposition of the extravasated blood and the exposed tissues is followed by a copious outpouring of blood-plasma and white blood-corpuscles, which inundates the wound with formative material. Here, however, everything is exposed to putrefaction and decay, and the decomposed products of destroyed tissue rapidly cause tissues previously healthy to become involved in the local death. These two processes correspond to two forms of inflammation, and have been called respectively the regenerative and the destructive. Where the process involves, however, the formation of a new tissue which cannot be said to represent strictly the regenerative process, but substitutes for the lost tissues material which may be classed as superfluous, this is known as the **productive form** of inflammation. The **exudative form** is characterized by a predominating and persistent exudation of blood-plasma from the tissues, the migration of the colorless blood-corpuscles or leukocytes being less marked than in the other forms.

The **regenerative form** of inflammation is that which occurs in every case of primary union. It likewise concludes the process of destructive inflammation whenever the latter tends to resolution, and invariably furnishes the material for building up the cicatrix.

The productive form of inflammation will be referred to in the discussion of diseases of separate structures as **adhesive** or **hyperplastic.** It not infrequently accompanies the regenerative, or closes the destructive form.

The exudative variety appears as the **serous, serofibrinous,** and **sero-hemorrhagic.** Finally, we recognize four varieties of the destructive inflammation, namely, the **suppurative,** the **purulent,** the **gangrenous,** and the **granulating.** These terms are applied according as one or the other of the conditions which they describe predominates. Sharply defined distinction between them cannot be made, however, because the suppurative may change to the purulent or the gangrenous, the granulating to the suppurative form, or *vice versa.* In fact, the four varieties are interchangeable.

Exudative Inflammation.—The lowest form of the exudative inflammation is the **serous.** In the present state of our knowledge it is presumed that this form is the result of noxious agents whose influence on the vessels is neither of a very intense character nor of long duration. Its most promi-

nent characteristic is an increased secretion of fluid which distends the connective-tissue spaces. This is followed by flat swellings of the soft parts, which, on palpation, feel doughy and can be made to diminish or to disappear altogether by pressure. Should the serous exudation occur in the rete Malpighii, the epidermis is elevated at one or more points, and blisters or blebs result. When this form of inflammation attacks mucous membrane, the exudation becomes mingled with the mucous secretion and thins it, so that a mixture of the two or a seromucous discharge is the result. In serous and synovial cavities the occurrence of this form of inflammation sometimes leads to enormous accumulations of fluid and occasional displacements of neighboring organs, as, for instance, in the chest when the pleural cavities are involved, or in a hydrarthrosis of the knee-joint with a resulting deformity. The term **inflammatory edema** is sometimes applied to this form of exudative inflammation. It should not, however, be confounded with ordinary edema, the result of mechanical obstruction to the circulation. It may be difficult to discriminate between the two, but it should be borne in mind that the former is characterized by the occurrence of fibrin in the exudation together with an occasional white blood-corpuscle, and is a true inflammation. In simple edema, however, the mechanical obstruction, while permitting the ingress of blood through the elastic capillaries, prevents its egress through the more readily collapsed veins. As a consequence of this passive engorgement, the serum of the blood escapes through the distended vessel walls into the surrounding connective-tissue spaces. The fluid which thus collects contains but little fibrin. The difficulty of distinguishing between these two conditions may be increased by the fact that venous obstruction may complicate the inflammation and give rise to passive edema in addition.

Serofibrinous inflammation is a serous inflammation, which, occurring in serous or synovial cavities, is characterized by a deposit of fibrin on the walls of the cavity. Sometimes the fibrin is present in the form of flakes floating in the fluid effusion. Here the fibrin has become coagulated and is precipitated. How far the various agents that induced the inflammation in the first place contribute in the furnishing of a fibrin ferment is, in the present state of our knowledge, a matter of speculation.

Serohemorrhagic inflammation is that variety characterized by the addition, to a greater or lesser extent, of red blood-corpuscles to the serous effusion. The secretion of a serous or synovial cavity may thus be stained red, like blood. The contents of a bleb or blister sometimes in like manner becomes colored. Occasionally a condition is observed which simulates that just described. It consists of a collection of blood-corpuscles outside the vessels, and is due to an extensive obstruction of the blood-current, a stasis in a circumscribed capillary area. Here the vessels are crowded with red blood-corpuscles which, as the result of pressure, pass through the dilated vessels singly or in groups. This process is simply mechanical and passive, and is known as **hemorrhagic diapedesis.**

In exudative inflammation there is generally an intrinsic tendency to recovery. A complete return to the normal is the rule. Even though large amounts of exudative material have been poured out into the connective-tissue spaces, this is soon taken up by the lymph-channels and no lesion demonstrable to the eye is left. It occasionally happens, however, particularly after inflam-

mations of large synovial closed sacs, as, for instance, that of the knee-joint, that a condition of recurrent or chronic inflammation supervenes and more or less of the secretion remains. In consequence of the access of new noxious agents, the exudative form of inflammation is sometimes converted into the suppurative or the purulent variety. From influences not at present well understood there may likewise occur a development of the adhesive or hyperplastic form.

Suppurative and Gangrenous Inflammations.—The most important form of inflammation from the standpoint of the surgeon is that known as the suppurative. Its peculiar and distinctive feature is the presence of pus. The most essential components of pus are pus-corpuscles and pus-serum. The former are for the most part the migratory white blood-corpuscles, reinforced by the proliferations of pre-existing tissue cells. Degeneration and decay seem to be necessary concomitants of pus-corpuscles. Subsequent to their escape into the perivascular spaces, they soon lose their characteristics as elements of the blood and differ essentially from those leukocytes still in the vessels. They are polynuclear. This at one time was supposed to be proof of the ability of pus-corpuscles to proliferate, but is now recognized as an evidence of degeneration. Their nuclei are pale, often hardly visible. The protoplasm is granular and contains drops of fat. Pus itself is a yellowish-white fluid of the consistency of milk or cream. Its specific gravity is about 1030. It is at first slightly acid, but afterward becomes alkaline by a process of decomposition in the course of which ammonia develops. When allowed to stand it separates into a sediment averaging from 10 to 16 per cent of the whole amount, and a clear supernatant fluid known as pus-serum.

As a rule, pus is nearly odorless. The sediment consists of the pus-corpuscles, pyogenic organisms, and fragments of broken-down tissue. Pus-serum is a pale, yellowish fluid corresponding to the blood-plasma which has left the vessels, from which, however, it often differs in chemic composition in addition to containing the products of the decomposition of tissues during the suppurative process, such as leucin and tyrosin.

Oxygen and hydrogen are absent from pus-serum, but nitrogen and carbon dioxid are always present. The proportion of potassium and sodium salts is somewhat larger than in blood. Among the albuminous substances found in pus-serum may be mentioned paraglobulin, an albuminate resembling casein but not precipitated by rennet, serum-albumin, and myosin. In addition to the constituents of pus already mentioned, occur flakes of coagulated fibrin, red corpuscles, and the rhombic plates of cholesterin. The last is found only in pus which has been for a long time inclosed in the living body. Rapidly advancing inflammation produces not rarely complete stasis and coagulation of the blood in isolated capillary areas, or even in the smaller arterial vessels. Under these circumstances, unless blood is supplied by collateral branches, large portions of tissue are liable to die, and as a consequence we have local death or **gangrene.** At the margin of this dead tissue, and maintained by it, there is a zone of suppuration which circumscribes and isolates it, and the whole process constitutes what is known as **suppurative gangrenous inflammation.**

The extent to which tissues become necrotic does not always depend on the degree or intensity of the inflammation present, but rather on the previous vitality of the structure involved. This is illustrated by the compara-

tive behavior of tendon and muscle. The former will slough readily from a slight inflammatory action, for, since it contains no blood-vessels, but only lymph-channels, the lymph-channels become easily obstructed and the tendon dies, as nutrition is thus cut off from it. The muscle, on the contrary, abundantly supplied with blood-vessels, resists the attack of the inflammatory process and survives.

The progress which the inflammation makes in the healthy tissues surrounding its focus depends partly on their condition, partly on the force of the lymphatic current, and perhaps to some extent on the ameboid movements of the migrating cells. The latter, if Hueter's observations are correct, may, by virtue of the organisms that they contain, become the bearers of infection.

The passive methods of propagation are of the greatest importance, however, in considering the spread of the inflammatory process. Advancing suppuration frequently follows the line of the lymphatics, and consequently lymphangitis is the not infrequent precursor of suppuration. The quality of the surrounding tissues is likewise to be taken into account. Loose tissues favor inflammation, solid structures resist it.

Phlegmonous Inflammation.—Phlegmonous inflammation is characterized by the rapidity with which it advances over large areas of flattened tissue. It may spread along the planes of connective tissue which lie between skin and fascia, or along the loose areolar tissue about the muscles, aponeuroses, or tendons. Phlegmons such as these are known as subcutaneous or subfascial. Phlegmons developing in special situations have been designated by special names, as, for instance, paronychia or panaris when they develop in the subcutaneous connective tissue of the palmar surface of the fingers.

Abscess.—Circumscribed collections of pus in large quantities are termed abscesses. A characteristic of abscess is the progress of pus in all directions from the original focus of infection with an inherent tendency to evacuate itself. This happens always along the line of least resistance. Hence abscesses either seek the surface or evacuate themselves into the cavity of some hollow viscus. It is notably easy to distinguish between phlegmon and abscess, although one condition may readily pass into the other, as, for instance, when a spreading phlegmon meets with a layer of more solid and resisting connective tissue, and, thus circumscribed, becomes practically an abscess; and *vice versa*, where an abscess slowly increasing meets with a layer of loose connective tissue and lights up there a rapidly advancing phlegmonous inflammation. While, however, the phlegmon always presents the character of an acute inflammation, the course of the abscess may vary according to the susceptibility of the tissues attacked. Accordingly the abscess is distinguished either as **hot (acute)** or as **cold (chronic)**.

The acute abscess is characterized by active hyperemia, marked local heat, and rapid destruction of tissue. The cold abscess, on the other hand, is accompanied by very slight local rise of temperature, and a comparatively slow progress of the suppurative process. The latter may, indeed, come to a standstill and remain in this condition for a considerable time. It is usually of tuberculous origin, and may be converted into an acute abscess if it becomes infected by the ordinary pus organisms.

An abscess cavity is usually surrounded by a zone of granulation tissue, which, whether the abscess is emptied by artificial means or spontaneously,

is the starting-point of the reparative process. This granulation tissue, by its augmentation, gradually fills up the cavity formerly occupied by the pus.

Sinus.—The final closure of an abscess may, however, be retarded by one cause or another. In such an event a communication is maintained between the surface on which the abscess discharges (be it skin or mucous membrane) and its old cavity, and the latter, narrowed down by granulation tissue, is called a sinus. A sinus may also be caused by the burrowing of the pus in different directions, a number of tortuous channels thus forming. Such a result is more likely to follow the spontaneous opening of an abscess, though it may happen after an insufficient or ill placed incision; for an opening which does not give free drainage, whether resulting from the natural process of ulceration toward the surface (the so-called pointing of an abscess), or made by the surgeon's knife, will in all probability lead to the formation of a sinus. On the other hand, a free opening made so as to afford a ready exit to the contents of the abscess offers the best security against such a result. The cavity of an abscess, as it becomes filled up with granulations and cicatricial formation, gradually contracts until the external communication is narrowed down so as to admit a fine probe. This finally closes under favorable circumstances; but if at the bottom of the abscess cavity there remains a portion of necrosed tissue, a foreign body or necrosed bone, though the granulations close around it and contraction takes place, there will still be a sinus leading to the offending body, which will not close. About the mouth of the sinus grows a mass of granulations, rich in organisms, which presents a peculiar puckered appearance comparable to the anus of a fowl. Again, the cavity may fail to close from inability of its walls to collapse, as in an empyema or a bone abscess. A diseased condition of the walls of the sinus may also hinder complete healing. In the case of persistent sinus due to the presence of a foreign body, necrosed bone, etc., the removal of the irritating cause is essential to the closure of the sinus, together with the thorough cureting of its walls.

Fistula.—Where an abscess opens into some natural cavity or hollow viscus, as, for instance, the rectum, vagina, or bladder, or into a natural canal, as the urethra or Stenson's duct, the resulting communication is called a fistula. Communications existing between normal cavities, as between the bladder and the vagina, are likewise called fistulas, and are known by special names which indicate the parts involved. Thus, a fistulous tract between the bladder and the vagina is called a vesicovaginal fistula. These will be described under their appropriate names.

Granulating Inflammation.—The formation of granulation tissue represents a stage between suppuration and cicatrization. It is the first step, so to speak, in the replacement of the defect caused by the injury and subsequent suppuration. There are other kinds of inflammation in which the formation of granulations precedes rather than follows suppuration, the latter occurring as a secretion from the granulating surface itself. The inflammation here seems to be due to some interruption of the normal course of the granulating process. Granulating inflammation is essentially chronic in its course, and occurs in individuals having those peculiar constitutional disturbances formerly comprehended under the name of scrofula; also in those suffering from syphilis, etc. Granulating inflammations, unlike the serous and suppurating forms, are not caused by common injuries involving the infliction of a wound and the

entrance of air and dust, if, indeed, traumatism enters into their etiology at all. They are most likely to occur in youth and attack the medullary substance of bones, the lymphatic glands, the joints, or the surface of the skin.

The differences between granulation tissue occurring in the border zone of an abscess and that resulting from a granulating inflammation are not at first well marked. Both consist of newly formed vessels between which are found the small, round, fixed, connective-tissue cells and white blood-corpuscles. Later on, however, they pursue a different course. The former shows an intrinsic tendency to cicatricial formation, while the latter seems predisposed to prolonged suppuration; if repair takes place at all, it is long delayed. Abscesses occur as a sequence of the granulating inflammation; these may find their way singly to the surface, or may unite to form one large abscess. Here again an apparent resemblance may be detected between this form and the common suppurative inflammation. It is, however, an apparent resemblance only, for in the ordinary suppurative variety the granulating zone soon shows a tendency to contract and so close the cavity, but in the granulating inflammation the granulations appear pale or faded. They become yellow or gray toward the periphery and advance slowly into the surrounding connective tissue. They break down readily, and the pus which results easily undergoes putrefaction. The granulating, or rather ulcerative, process may extend in all directions, sinuses forming which lead along the connective-tissue planes, and, what is of most importance to the surgeon, to the original focus of inflammation (medullary substance of bones, etc.). The *clinical characteristic of the granulating inflammation, therefore, is the fact that it does not lead to the formation of solid cicatricial tissue. On the contrary, after the pus evacuates either into the surrounding tissues or externally it continues to advance and to involve contiguous structures by a process of progressive ulceration.* Under certain circumstances this form of inflammation is characterized by a dry condition of the parts rather than by the secretion of pus. Matters of a grayish-yellow color and of the consistence of soft cheese are found in the ulcerating tissues ; this process is known as the **cheesy metamorphosis,** and is sometimes called **cheesy inflammation.** The albuminoid (nitrogenized) substances resulting from the breaking down of tissue seem to degenerate into a fatty substance which contains many living organisms. This cheesy metamorphosis occurs particularly in lymphatic glands.

In granulating inflammations, histologically we find small round-cells, sometimes gathered in groups and often surrounding a large cell with many nuclei, the so-called **giant-cell,** which in turn is surrounded by a network of capillary vessels. These collections resemble the tubercles found in cases of diffused miliary tuberculosis, scattered in numberless masses throughout the internal organs. They were formerly believed to be identical with these tubercles, though local and less dangerous to life. Since the discovery of the tubercle bacillus by Koch, the presence or absence of this organism will decide as to the tuberculous character of the inflammatory process.

ETIOLOGY OF INFLAMMATION

Process of Putrefaction.—Putrefaction is the disintegration, in the presence of moisture, of organic nitrogenous matters, particularly the albuminoids, into their constituent parts, the nitrogen uniting with the hydrogen to form ammonia, the carbon with the oxygen to form carbon dioxid, the hydrogen with the oxygen to form water.

During this process there is developed an intermediate class of compounds which resemble the vegetable alkaloids in their chemic composition and are powerful poisons. From the fact that certain substances of this class were first discovered in the dead body, they have been termed ptomains (πτῶμα, a corpse).

The conditions necessary for putrefaction are the following: (1) heat of a moderate grade; (2) moisture; (3) certain agents competent to decompose organic matter when brought in contact with it and called, by the generic terms, bacteria, microbes, or microorganisms. As early as 1835 Cagniard-Latour discovered in the fermentation of wine small globular structures, increasing partly by fission, partly by spores. Schwann, in 1837, by a series of experiments demonstrated the existence of microorganisms in the air which, when brought in contact with a proper nutrient medium, increase in number and produce the phenomena of putrefaction. He likewise showed that these microorganisms are destroyed by heat. A year earlier (1836) Franz Schultze made a series of experiments whose object was to refute the doctrine of spontaneous generation, and showed that air passed through sulfuric acid becomes sterile.

Subsequently Schröder and Dusch showed that neither heat nor sulfuric acid is necessary in order to free the air from so-called zymotic agents, simple filtration through loose cotton being sufficient. This demonstrated the physical character of the germs.

Pasteur's famous experiments (1861) still further simplified the matter. He showed that not only can air be deprived of its power of infection, but that the agents inducing the fermentative process are not conveyed through a fine glass tube if the latter is bent in a downward direction, though the air enters freely. In other words, these agents, though microscopic, partake more or less of the physical properties of dust and obey the law of gravitation.

While, by the series of experiments above alluded to, it was clearly demonstrated that fermentation and putrefaction are due to the presence and growth of microorganisms, it still remained to apply this knowledge to the relation of the process of putrefaction to inflammation. Lemaire, in 1860, studied the effects of coal-tar preparations on the healing process in the light of the Schwann-Pasteur theory as to the origin of wound putrefaction. The results, however, were neither satisfactory nor conclusive enough to attract more than passing notice. It was reserved for Joseph Lister to prove the definite relations which existed between microorganisms and inflammation, and to this now famous surgeon belongs the credit of demonstrating beyond the shadow of a doubt that the presence and development of germ life in wounds is the cause of suppuration, and that the so-called wound sequels, inflammation, septicemia, pyemia, erysipelas, etc., are due to microorganisms.

Basing his theory on the well-known experiments of Schwann, Schröder, Dusch, and Pasteur, he reasoned that if he could protect fresh wounds from the putrefactive processes caused by the organisms of putrefaction shown to be present in the air, or could treat germs, which might gain entrance into the wound, so as to inhibit their growth, the interruption of the healing process by those accidents which were at once the scourge and opprobrium of surgery could be prevented. To this end he labored assiduously, and finally developed a method of wound treatment which in its beginning was intended only for operation wounds. The agent he mainly employed was carbolic acid, at that time the best-known antiseptic. The surroundings of the intended wound, the instruments, the hands of the operator, the sponges and dressings, were all treated with a solution of carbolic acid. The air of the operating room was filled with a nebúlized spray of the same antiseptic.

The successes attained by this method were remarkable, and, though at first sharply criticized, it was finally adopted by the profession throughout the world. As a result, large gaping wounds healed without suppuration and by first intention, and this became the rule rather than the exception when Lister's method was rigidly followed. Proof trod on the heels of proof until the era of antiseptic surgery was fairly established in the world's history, and became unalterably associated with the name of Joseph Lister, to whom humanity owes a debt that it can never repay.

While Lister was pursuing his experiments in the Royal Infirmary at Glasgow, other observers were following up elsewhere the discoveries of Schwann and applying them to medical science. In 1868 C. Hueter, of Greifswald, in a case of hospital gangrene, observed many nests of microorganisms; Klebs, in 1871, described growths found in the wound and its neighborhood in cases of septicemia and pyemia, and to these organisms he gave the name "microsporon septicum." He further suggested that these destroyed the tissues and induced suppuration, and by penetrating into the blood-channels and lymph-channels and being thus transported to different parts of the body, set up a similar process of suppuration. Then came Lister's announcement of the nonsuppurative course of wounds under carbolic dressings. This confirmed the relation of pathogenic organisms to wound diseases.

The microorganisms may enter the wound either from the surface of the patient's body, from his clothing, or from contact with dust-laden and hence germ-laden air. Fluids brought in contact with the wound, if not sterilized, may also prove to be carriers of infection. The surface of the vulnerating body may infect the wound in the act of inflicting it; so may the surgeon's knife, his hands, or those of an attendant, if proper and adequate precautions have been neglected. In short, infection may be conveyed to a wound by contact with any nonsterile substance. Common air is full of organisms. If a saucer of perfectly sterilized jelly is allowed to remain exposed but for a few minutes to permit the deposit of organic dust, though subsequently protected from contamination, it will in the course of a few hours show numbers of different colonies of germ life growing on its surface. Certain of these bacteria are sure to be putrefactive organisms or pus-producers, and they soon decompose the gelatin. These, when deposited by the air in an unprotected wound, produce

the same phenomena of putrefaction and suppuration as well. The albuminous secretions of the wound, its moisture, and the natural heat of the part furnish all the conditions most favorable to the multiplication of microorganisms and the subsequent development of putrefactive processes. Autoinfection may then take place from the putrid or decomposing secretions.

The interesting question has arisen whether the fluids of the body in a normal state do not themselves contain organisms, which, poured out with the blood, lymph, etc., in the wound and thus brought in contact with the air, multiply and so produce decomposition independently of germ infection from without. Many interesting experiments have been made with the view of clearing up this point. Results widely differing have been obtained at the hands of equally competent observers, so that it is difficult to reconcile statements so at variance. Billroth's and Burdon-Sanderson's experiment consisted in the rapid removal of portions of a solid viscus of animals and their immediate transference to heated paraffin which completely enveloped the mass on cooling. These underwent putrefaction at about the usual time. No provision was made against the contact of air with the tissues when in transit, however, and no matter how quickly they might have been removed, infection was nevertheless possible. On the other hand, carefully conducted experiments in the hands of Pasteur, Koch, Cheyne and others have pretty conclusively proved that, as a rule, the blood and tissues of a healthy body are free from microorganisms. Nevertheless the body may appear to be healthy and yet contain bacteria. Klebs, after he had made, with negative results, quite a number of carefully conducted experiments on dogs, found microorganisms in an animal apparently in perfect health. Investigation, however, revealed that this identical animal had been the subject of a former experiment in which injections containing zymotic organisms had been made into a vein. As a result the dog had suffered severely, but had apparently recovered. It may be fairly inferred that some of these organisms had remained in the body and thus caused an error in the subsequent experiment.

The observations of Klebs gave rise to the further suggestion that blood which has been infected may, even after the lapse of a considerable period, under proper conditions, such as the reception of an injury, give rise to the active processes described. Experiments made by Chauveau bearing on this point are very striking. Male goats were injected with cultures of microorganisms and the testicles afterward subjected to the subcutaneous separation of the spermatic cord in such a manner as to rob them of their blood-supply. Rapid putrefaction followed, just as if the organs had been infected from without. Animals thus treated, but not injected with pathogenic organisms, suffered simply from atrophy. In another experiment the animal was subjected to the same operation on the left testicle, prior to inoculation, and on the right after inoculation; the latter alone underwent sloughing and putrefaction.

Occurrence and Spread of Microorganisms.—Death and decay are of daily and hourly occurrence wherever animal and vegetable life exist. In the frozen regions of the north, however, decay does not follow dissolution, for, of the three factors necessary to reproduce microbic life, heat, moisture, and organic matter, the first is wanting, and therefore the process of putrefac-

tion is inhibited. The undecayed remains of long extinct mammoths in Siberia are examples of this. So, too, in certain portions of the tropics, because of the extreme dryness of the air, rapid desiccation takes place and the dead body, deprived of its moisture, simply mummifies. Here the second factor, moisture, is absent. This desiccating process is sometimes taken advantage of in preserving meats, as, for instance, the "jerked beef" of the plains.

Except under these exceptional circumstances, however, dead animals or vegetable tissues decay and become the birthplace of new germs of putrefaction to be taken up by the atmosphere as dust when the process of disintegration has advanced far enough. This cannot happen while the decaying mass is in a moist condition, but only after its evaporation and the conversion of the dried and broken-down tissues into dust, which, disseminated through the air, furnishes constant accessions to germ life.

At great elevations, therefore, beyond the level at which vegetative life can grow, and beyond the confines of crowded communities, it will be found that comparatively few microorganisms are present in the atmosphere. The classic experiments of Tyndall, carried on in the Alps, show this to be true. On the contrary, it is found that in swampy regions where vegetation is constantly undergoing putrefactive changes, and in large cities and thickly populated portions of the country where more or less decaying animal matter exists, the conditions are favorable to the development and dissemination of germ life. These germs may be carried out to sea by the wind or transported on ships, and become foci of infection in distant regions. In general, however, it may be said that on the high seas the air is practically sterile, being free from dust.

In pre-aseptic times surgical practice suffered greatly from a want of knowledge concerning the dissemination of wound infections. In improperly built, poorly ventilated, and unclean hospitals, where many patients with suppurating wounds were crowded together, the putrefying wound secretions furnished to the atmosphere an unlimited supply of germs. Deposited in connection with dust on instruments, dressings, and the persons of attendants, these organisms were conveyed to fresh wounds, which, in turn, became infected, and furnished new sources of infection and reinfection; this constituted a vicious circle of events.

SURGICAL BACTERIOLOGY

In the preceding pages reference has been made to bacteria, or organisms, microscopic in character (microorganisms), and the relation which these bear to the processes of putrefaction, and, through their irritating influences, to the etiology of inflammation. Since this subject constitutes the essential groundwork of modern surgical practice, it demands a fuller discussion in this connection.

It has been happily stated that every operation in surgery is an experiment in bacteriology (Welch). It is, therefore, essential that the surgeon should have at least an elementary knowledge of the organisms which commonly infect wounds, in order to exclude them intelligently. Familiarity with laboratory methods will emphasize the precautions to be taken during an operation and will contribute to the employment of intelligent means for the purpose of securing asepsis or antisepsis. A single act of carelessness or over-

sight in the series of acts that make up an operation is sufficient to vitiate all the precautions that have been taken to keep the wound aseptic, and it is certain that unless the surgeon understands the rationale of laboratory procedure he will often defeat his own best efforts by mistakes which he would otherwise avoid. Unless the methods of the surgeon, together with all the paraphernalia of operation, are exact and precise, and competent to attain the ends sought, namely, perfect sterilization of the wound and its surroundings, the antiseptic and aseptic procedure will prove a snare and a delusion, for it will induce a false sense of security in the operation which may prove dangerous and even fatal to the patient.

Bacteria.—Bacteria are unicellular vegetable organisms, multiplying by fission. They are the active agents in that process of degeneration in organic substances which we call putrefaction. They may increase and produce their characteristic phenomena of decay only in dead tissues, whether plant or animal, in which case they are called **saprophytes;** or they may require living tissue for their development, when they are called **parasites.** Finally, they may flourish under both conditions, when they are termed **facultative parasites.** As strict parasites, they may or may not be disease-producers.

With regard to their shape, bacteria are divided into two classes: (1) **bacilli,** rod-shaped organisms, longer than broad; (2) **cocci,** the spheric forms. The bacilli, in turn, when curved are called **comma bacilli.** When comma bacilli, increasing as they do by fission, are grouped end to end, forming a spiral, such a group is called a **spirillum.**

The cocci are subdivided, also, according to their grouping, the different and characteristic forms of the various species depending on their methods of subdivision when undergoing fission.

When subdivision takes place in one direction only, but that indifferent, we then have a number of cocci, either solitary or occurring in irregular groups, and to these the term **staphylococci** is applied. When fission takes place in one direction only, but always in the same direction, the cocci are then associated in chains and are described as **streptococci.**

If the cocci occur mostly in pairs, they are termed **diplococci.** When fission takes place in two directions, then the cocci occur in groups of four, and are called **tetrads.** When division occurs in three directions, the so-called packet shapes are formed, containing eight elements. These cocci are called **sarcinae.** Other subdivisions and varieties of bacteria occur and have been described and classified, but they have not as yet been shown to be important as disease-producers.

With regard to the bacilli, it is to be noted that many varieties in the shape of rods occur. Some are scarcely longer than they are broad, as, for instance, Bacillus prodigiosus, which for this reason was for some time described as a coccus. Some rods have their ends well rounded, while others seem to be cut off square.

The size and length of the rods may vary somewhat, even in the same species, so that quite long threads may occur together with shorter rods. So also there may be a distortion of form in old and worn-out cultures, swellings and constrictions quite different in form from the original bacillus. Such forms are known as involution forms.

Bacteria are further classified with regard to certain peculiarities in their growth, as **liquefying** and **nonliquefying** organisms, **aerobic** and **anaerobic.**

The liquefying organisms have the property of liquefying gelatin. This they do by secreting a peptonizing ferment.

Anaerobic bacteria are those that grow only when oxygen is excluded from the nutrient medium. Aerobic bacteria grow only in the presence of oxygen, while **facultative** organisms grow either with or without oxygen. Some anaerobes will tolerate this gas in minute quantities, while others require its absolute exclusion in order to grow. Such are called strict anaerobes.

All bacteria multiply by fission. The cocci never increase in any other way, as far as we know at present. An important modification of the process of reproduction, known as **sporulation,** occurs in many of the bacilli. When this takes place, the individual rods develop in their substance a small and highly refractive oval granule, which, increasing in size, finally escapes from the parent cell. This is the spore, which in turn, under favorable circumstances, again changes its form and passes into a shape exactly similar to that of the parent cell. The spore may be considered as the fruit of the original plant, and develops only under circumstances favorable to the growth of the parent cells. It is not, as was formerly supposed, a result of unfavorable environment. Spores differ from the bacilli in one very important particular. They possess an extraordinary power of vital resistance far in excess of their originating rod forms. Many spores resist prolonged boiling, desiccation, and the action of chemic agents quite sufficient to insure the destruction of the plants themselves. It will be seen at once how important to the surgeon is a knowledge of this peculiarity of the spore. All bacilli are not known to be spore-bearers, nor are any of the cocci. In the nonspore-bearing species certain individual members of a group appear under the microscope to be slightly larger and more refractive than the others. There is reason to believe that they are more refractory also. These are supposed to take the place of the spores, and are called **arthrospores.** Sporulation in the spheric form, if it ever takes place, is thus accomplished.

Ptomains.—In the life processes of animals we have, as a result of tissue metamorphosis, the formation of certain products such as carbon dioxid, urea, etc. So it is with the higher order of plants. They give out oxygen and absorb carbon dioxid as a result of their development and growth. Not dissimilar are the bacteria in that they, too, in the course of their life processes originate certain new substances as the result of the tissue changes which take place during the process of decomposition. These substances, as has been before stated, are called ptomains.

There are both poisonous and nonpoisonous ptomains. In the pathogenic species of bacteria in many cases the specific ptomain which they originate is the active agent in the production of disease. This is notably true of tetanus, a bacterial disease in which the nervous phenomena are entirely due to the ptomain formed by the bacillus of tetanus. During the progress of wound diseases the high temperatures and the vascular paralyses which occur are caused by the action of these poisonous substances in the circulation. Suppuration itself can be produced by the ptomains alone of certain of the pus organisms. The blush of erysipelas is probably due to a vascular paralysis caused by the local action of a poisonous, alkaloidal substance formed by the Streptococcus pyogenes, and to the same cause are due the high temperature and other phenomena of fever.

Culture Methods.—Not until it was practicable to cultivate bacteria on artificial solid media was it possible to isolate and classify the different varieties for observation and experiment. The world is indebted to Robert Koch for the media which are now used in all laboratories for the cultivation of these organisms. The fluid medium which is most generally used is Koch's bouillon. The solid media are nutrient gelatin, nutrient agar, and coagulated blood-serum.

The bouillon is made as follows: One pound of lean beef is finely chopped and added to one liter of water, then boiled for half an hour in a glass flask. The infusion is then filtered, neutralized by adding drop by drop a saturated solution of sodium carbonate, and again boiled for an hour to clear it. A 0.5 per cent solution of sodium chlorid is usually added. The bouillon is subsequently poured into test-tubes which are sterilized after the following method, known as **fractional sterilization**: The tubes are first plugged with common non-absorbent cotton and subjected for one hour to a temperature of 150° C. in a hot-air sterilizer. The bouillon is then poured into the tubes, which are re-plugged and placed in a cage made of wire cloth, and this in turn is put in an Arnold steam sterilizer and exposed to flowing steam half an hour each day for three successive days. The object of this method of sterilization is to permit the spores which have resisted the first steaming to develop into cell forms during the intervals, and then to destroy them by the second and third sterilizations. This method is thoroughly effective. It is to be noted here that all cell forms of bacteria perish after an exposure of ten or fifteen minutes to streaming steam, and all pathogenic bacteria, with the exception of the anthrax bacillus, perish after exposure to a temperature of 80° C. (176° F.), yet there are spores which resist prolonged boiling, and it is to permit such spores to germinate into the less refractory vegetative forms that the method of fractional sterilization has been adopted. One exposure of an hour to **wet steam under pressure** (35 to 40 pounds per square inch) will destroy all spores, but as this requires special apparatus the method first described is that usually adopted.

The nutrient gelatin is made as follows: An infusion of meat is made by adding to one liter of cold water a pound of well-chopped beef. This is placed on ice for twenty-four hours and the expressed and filtered infusion then cooked, filtered, and neutralized by the addition of a solution of sodium carbonate, drop by drop. To one liter of this "flesh water" is added 10 grams (154 grains) of peptone and 0.5 per cent of sodium chlorid. Ten per cent of gelatin is then added to this mixture, which is boiled after the gelatin has been allowed to soak for a time. In order that the gelatin may be perfectly transparent it is necessary to clear it of insoluble precipitates, which, if not removed, would render it cloudy. This is done by adding the albumen of one egg to 100 grams (about 3 ounces) of cold water. This is gradually poured into the gelatin mixture, which is stirred constantly with a glass rod. The whole is then boiled for ten minutes, when the coagulum of the egg-albumen comes to the bottom of the vessel, together with the insoluble residue which it is sired to separate from the nutrient medium. The gelatin thus prepared after filtration is poured into test-tubes to about one-third of their capacity. This must be done carefully without wetting the upper portion of the tube, otherwise the plug of cotton will stick to the tube as the gelatin sets, and it will be

difficult to remove it. The tubes containing the gelatin are placed in a cage made of wire cloth, put in an Arnold sterilizer, and subjected to flowing steam for half an hour; this is repeated three times at intervals of twenty-four hours, in the same manner as the bouillon. Too prolonged boiling, it is to be noted, will deprive the gelatin of its property of solidifying when cooled.

The **agar jelly** is also made in a similar manner, except that a vegetable gelatin called agar-agar is substituted for the ordinary gelatin. This is the product of a species of seaweed in Japan and has a melting-point much higher than that of gelatin. It is to be added to the flesh peptone solution in the proportion of 1 to 2 per cent.

This medium is more difficult to make than the ordinary nutrient gelatin, as it filters less readily and is consequently more troublesome to clarify. For filtering both gelatin and agar preparations it is desirable to use a hot-water filter. This is simply a double-walled copper receptacle shaped like a funnel and filled with water which is kept heated by a number of gas jets issuing from a circular hollow tube perforated for the jets and fastened in the ordinary way to a retort stand. The glass filter is slipped inside the hollow copper funnel, and in this manner the gelatin or agar is kept hot while filtration is going on. In the absence of such an apparatus the ordinary glass funnel may first be heated by boiling water, and after the agar or gelatin is poured therein its walls may be kept hot with cloths wrung out of boiling water and continually renewed.

A modification of the ordinary nutrient agar may be prepared by the addition of 5 per cent of glycerin. This is the so-called **glycerin agar,** and is a useful medium for the tubercle bacillus, which will not grow on the ordinary media. After the addition of the glycerin, which is often acid, the agar must be carefully neutralized as before. It is important that all the media should be neutral, as some organisms resent even a trace of acid.

Human blood-serum is often used for the cultivation of organisms which refuse to grow on other media. It is usually obtained from maternity hospitals and is sterilized in what is known as a blood-serum sterilizer. It is a useful medium for the diplococcus of gonorrhea, which will not grow on any other medium.

The **common potato** is sometimes used as a culture-medium. To prepare it for use, the tubers must first be well scrubbed with a brush in a solution of bichlorid of mercury, 1:500, and then well rinsed in sterilized water. Potato cylinders may then be cut with an apple-corer and sliced obliquely to their axis in order to secure a broad flat surface for inoculation. This is the method of Bolton. These pieces are then placed in test-tubes, plugged in the ordinary manner, and sterilized as usual.

All these different media have their own peculiarities and individual uses in laboratory practice. For hospital use, the chief advantage of the bouillon is the certainty with which the sterility of sutures and ligatures may be tested. Dropped into a test-tube of bouillon, every portion of the material to be tested comes in contact with the bouillon, which thus offers a more rigid test than solid media.

More than one organism may be lodged on a suture or ligature, and when these grow together in a fluid medium there is no way of isolating and separating the different species from one another. Thus no conclusions with regard

to the pathogenic power of different organisms could possibly be reached, unless we possessed some means of separating them and testing their properties individually. Before the introduction of solid media this was a most difficult and uncertain process. In 1881 Koch introduced what is known as the **plate method** of isolation, which is as follows: Three test-tubes of nutrient gelatin are used, numbered in rotation, one, two, and three. Heated until the gelatin is fluid, but at a temperature below 40° C. (104° F.), number one is inoculated with a minute quantity of the material whose organisms it is desired to isolate. This is done by means of a fine platinum wire in the end of a glass rod, the point of which being bent on itself forms a fine loop. To sterilize the wire, it is first heated to redness in a Bunsen burner and then made to take up in its loop a minute quantity of the material to be used for inoculation. The wire loop is then plunged into the first tube, the gelatin being well agitated. From tube number one, thus inoculated, a sowing is in the same manner implanted in tube number two, and in like manner number three is inoculated from tube number two, the wire being heated to redness before each sowing to insure its sterility. Now, it is evident that this is a process of dilution, and that each successive tube will contain organisms rapidly diminishing in number. Three sterilized glass plates are then prepared and leveled. The contents of tube number one are poured on plate number one, and so on, so that finally we have three plates covered with a thin layer of solidified gelatin.

In plate number one so numerous are the organisms which have been diffused through the gelatin that the colonies which start from each individual coalesce, so that they cannot be isolated, but in plate number two, after a time, numerous isolated points may be seen, each of which is a colony growing from a single spore or plant, and therefore an unmixed growth. In plate number three, as the individuals are far fewer, the colonies are more widely scattered, so that the whole plate may contain fewer than a dozen colonies. These plates are all, of course, protected from the atmosphere after sowing, so as to prevent the introduction of organisms from the air. This may be conveniently done as follows: Two circular glass dishes with straight sides about an inch and a half high are used, one just small enough to fit inside the larger dish. The plates, suitably elevated, are placed in the larger dish and covered by the inverted smaller dish. Sufficient water is then poured into the larger dish to make a water seal, and the plates are then left to develop their growth. Of course, the removal of the covering dish exposes the plates to the contamination of organisms floating in the air, and this method has been modified by Petri with a view to minimizing the chances of contamination. He pours the inoculated gelatin into three shallow circular dishes with straight sides and covers each dish with one similar, but a little larger. These little receptacles, about six inches in diameter, are known as **Petri dishes.**

Most organisms grow more or less rapidly at a temperature of 22° C. (70 F.), or that of an ordinary room. They all grow much more rapidly, however, at blood-heat, and some refuse to grow at any other temperature. It therefore became necessary to devise an incubator which could be maintained steadfastly at the desired heat by means of a thermostat. Koch's device is simply a double-walled box or oven mounted on a standard. The space between the walls is filled with water, to which heat is communicated by a small flame under the bottom of the oven. Radiation is prevented by covering with

felt the outside of the oven. Such ovens usually have double doors, sometimes triple, the inner ones being of glass (Fig. 1).

There is usually a water-gage at the side to show the height of the water between the double walls, and an orifice in the top through which a thermometer may be passed.

There are numerous thermostats in use at present, all depending on the expansion of a column of mercury to regulate the flow of gas to the burner, the mercury, as it rises, reducing the size of the aperture admitting the gas, increasing the size as it falls. The Dunham thermostat is represented in Fig. 2. It is usual to interpose a pressure regulator between the house system and the thermostat in order to obviate the effects of

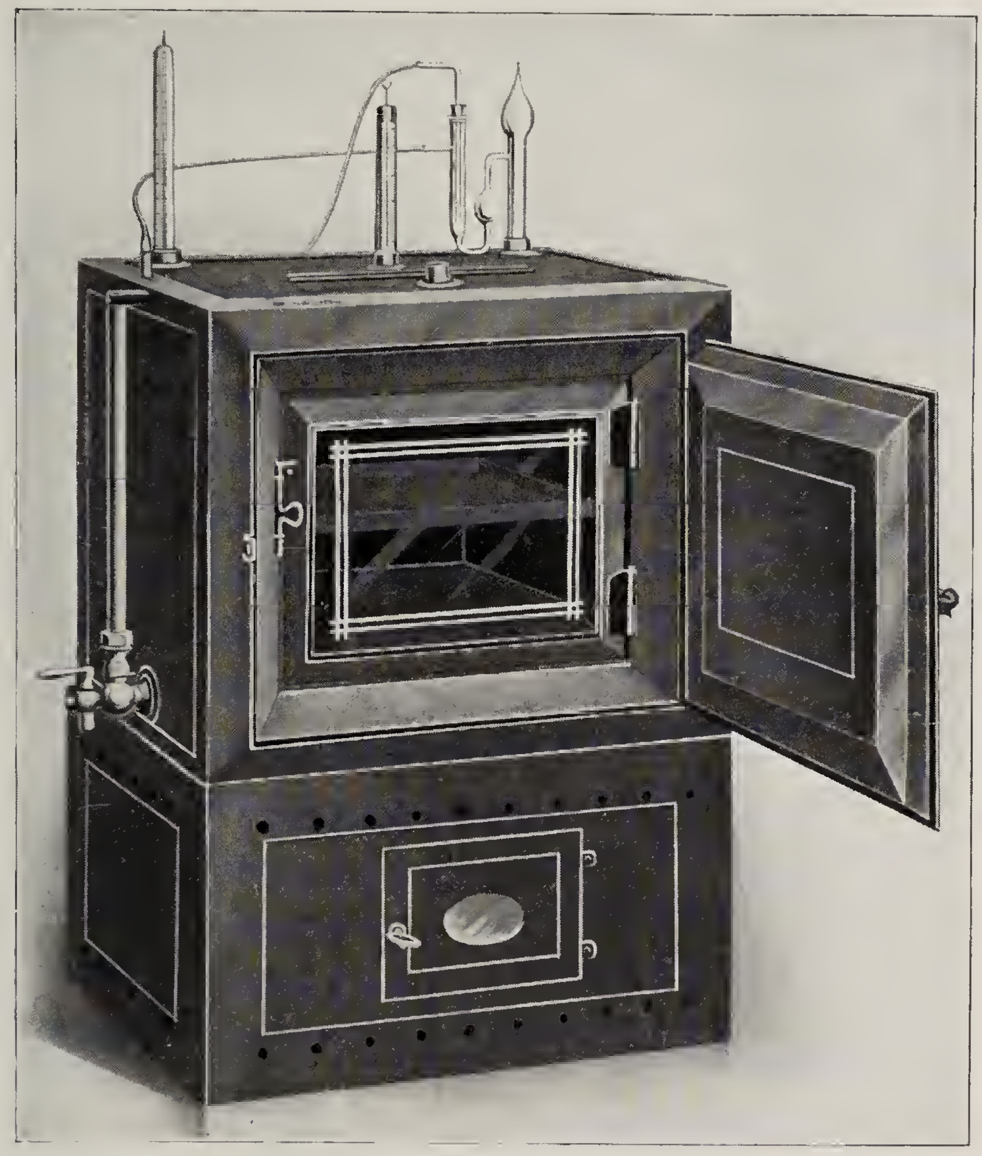


Fig. 1.—Laboratory Incubator.

changes of pressure in the mains (Fig. 3). The small jet at the burner is protected from accidental extinction by a cone of mica.

A hot-air oven is useful in a laboratory for the purpose of quickly sterilizing the test-tubes with their cotton plugs previous to filling them with the various media. This is simply a box of Russian iron with double walls and suitable shelves. Heat is furnished by a nest of Bunsen burners underneath the bottom. A temperature of 150° C. for one hour will completely sterilize both tubes and plugs.

Identification of Bacteria.—With regard to the **naked-eye appearances** of bacteria as they grow on the different media, these organisms differ widely. In stick cultures some grow within the narrow boundaries of the stab, while others send out branching growths therefrom in great exuberance.

Color is moreover an important point of distinction between different organisms, and has given rise to a classification in which these organisms are divided into chromogenic and nonchromogenic species. One produces a bright red growth, others a deeper shade; some, again, are orange, some yellow, and the organism of blue pus imparts a peculiar bluish-green tint to the agar. Color, however, is not a test of pathogenic power, many of the pathogenic organisms being nonchromogenic and a dirty white.

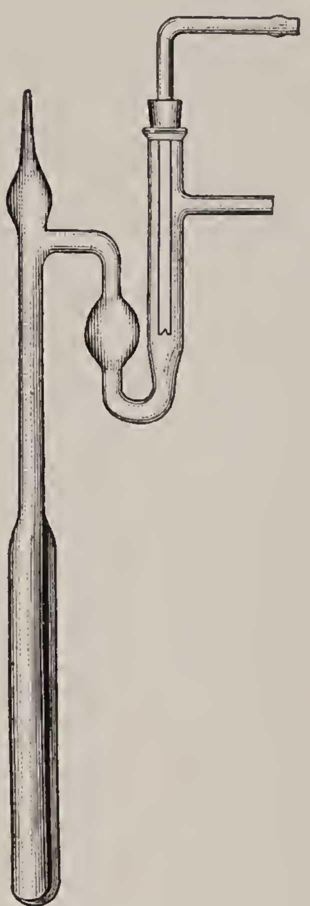


Fig. 2.—Dunham's Thermostat.

The **odor** of certain organisms is to some extent characteristic and furnishes a means of identification. Thus, Bacillus ureae has an odor like that of decomposing urine. The malignant edema bacillus generates a putrid, offensive gas.

Some organisms liquefy gelatin and give a characteristic funnel shape to the area of liquefying gelatin stab culture, and again the liquefying organisms differ widely in the rapidity with which they bring about liquefaction.

Microscopic Examination.—It is to be seen, therefore, that the organisms may differ in many particulars, and that it is necessary to take all these into consideration before we appeal to the microscope for final adjudication. Indeed, were we to trust to the microscope alone for our means of identification, very few, if any, are the bacteria which we could identify. It is as necessary to know the behavior of organisms on culture-media as it is to be able to recognize their forms under the microscope. Indeed, we gain more information as to the identity of a particular organism by observing the peculiarities of its growth than we do by the microscope, which may simply confirm our previous conclusion.

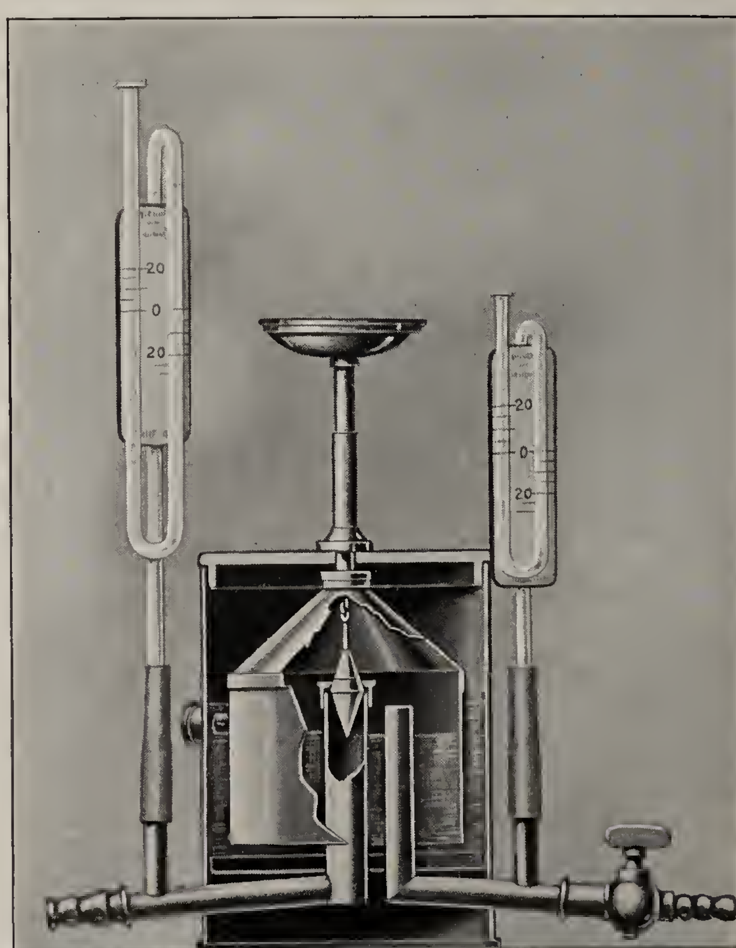


Fig. 3.—Moitersseur's Pressure Regulator.

Methods of Staining.—In the minute quantities which are required for the purpose of microscopic examination all these organisms are colorless, chromogenic, or nonchromogenic. It thus becomes a matter of difficulty to see them well under the microscope, and hence for purposes of examination they are stained. We are indebted to Weigert for this very great addition to the technic of the microscopic examination of these organisms. The anilin dyes are used because they are readily absorbed by the protoplasm of the cells, the spores remaining unstained, except by the aid of special processes.

Since Weigert's discovery many methods of staining bacteria have been invented. Only three formulas will be given here, which will be quite sufficient for the purposes of the general surgeon. For a general stain that known as the **alkaline methylene-blue** (Löffler) is probably the best. It is made as follows:

To 30 c.c. of saturated alcoholic solution of methylene-blue add 100 c.c. of a solution of caustic potash, 1:10,000. This stain may be kept in a bottle through the cork of which has been thrust a dropping tube with rubber compressor. It is a most useful stain. In permanent preparations, however, it will fade.

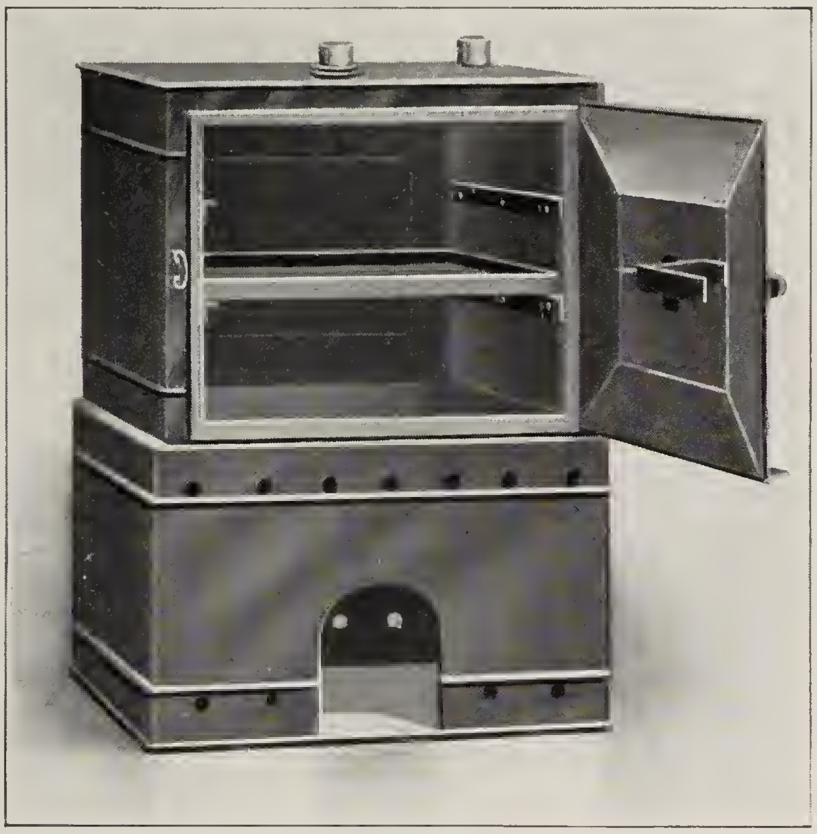


Fig. 4.—Hot-air Sterilizer.

In examining bacteria in pus, sputum, etc., the dried albumin also takes the stain. This is often confusing, and it becomes desirable to remove the coloring in some way and yet leave the bacteria stained. Gram's method does this satisfactorily. Some organisms, that of gonorrhea, for instance, do not retain their color in Gram's stain, so that this method may be used for the purpose of differentiation. The Ziehl-Neelsen method removes the stain not only from extraneous material, but from all organisms except Bacillus tuberculosis, so that this also is available for the purpose of differential diagnosis.

In the **method of Gram** there are two solutions, a stain, and a decolorizing agent:

Gram's Stain.

Saturated aqueous solution of methyl-violet.

Decolorizing Solution.

Iodin, 1 part; potassium iodid, 2 parts; water, 300 parts. The preparation is first stained, then immersed in the decolorizing solution for a minute or longer, then cleared.

The Ziehl-Neelsen formula for staining tubercle bacilli is as follows:

Carbol-fuchsin.

Fuchsin	1 c.c.
Alcohol	10 c.c.

When dissolved, add 100 c.c. of a 5 per cent solution of carbolic acid.

All these stains require to be freshly made every now and then, as by long standing they deposit the dye in the walls of the bottle and so lose in efficiency.

Method of Examination by the Microscope.—A minute quantity of the organism to be examined is taken up in the previously flamed loop of platinum wire and spread very thinly over a cover-glass (**smear preparation**). If neces-

sary, the smear may be still further attenuated by the addition of a loopful of sterilized water. The preparation is then allowed to dry spontaneously. The cover-glass is then seized in a pair of forceps and passed three times through the flame of a Bunsen burner, smeared side up. If the alkaline blue solution is used a drop of this may be placed on a glass slide and the cover-glass then placed, smeared side down, on the drop of stain, so as to exclude air-bubbles. The surplus stain which exudes from the edges of the cover-glass is then to be blotted off by a piece of filter-paper placed over the slide and cover-glass, and gently pressed thereon. Sufficient stain will remain to keep the cover-glass fixed to the slide. A drop of cedar oil is then placed on the cover-glass and the specimen is ready for examination with the homogeneous immersion lens. In the Gram method, after the specimen has been stained in the methyl-violet solution and subsequently decolorized as before directed, the decolorizing fluid is to be washed off with sterilized water and the cover-glass placed on the slide and treated as before. There must always be some fluid between the slide and the cover-glass, but not sufficient in amount to float it. If during the examination the fluid evaporates, it must be renewed by placing a drop of water at the edge of the cover-glass, which will be drawn underneath by capillary attraction. Specimens when stained may be permanently mounted in Canada balsam after they have been dried. For staining tuberculous sputum, etc., the application of heat is necessary, if it is desirable to work expeditiously. This may be done in the following manner: The preparation having been made and dried in the usual way, the cover-glass is flooded with the carbol-fuchsin solution and held over the flame until it boils vigorously for half a minute. The stain is then washed off and the slide is in like manner flooded with the decolorizing solution. If this is left too long in contact with the preparation, the bacilli themselves may be decolorized, especially if faintly stained. A little practice will teach the observer the proper interval, which is usually not over one minute, and sometimes less. The cover-glass held against a white surface should show but a trace of color. This rapid method is useful for diagnostic purposes, but the evaporation of the stain when boiled leaves unsightly crusts at the edge of the cover-glass, so that, for a permanent mount, it is better to leave the specimen overnight in a watch-glass filled with a cold solution of the carbol-fuchsin, the decolorizing method being identical with that first described.

Common Pus Organisms.—It now becomes necessary to describe those organisms that the surgeon will encounter in wounds and in certain diseases which require surgical interference. First and most important are those that induce suppuration. They are the following: **Staphylococcus pyogenes aureus, Staphylococcus pyogenes citreus, Staphylococcus pyogenes albus, Staphylococcus epidermidis albus** (Welch), **Streptococcus pyogenes,** and, rarely, **Bacillus pyogenes soli** and **Bacillus pyocyaneus.** Under the microscope Staphylococcus pyogenes aureus, Staphylococcus pyogenes citreus, and Staphylococcus pyogenes albus do not differ from one another, nor could they be thus distinguished. When grown on nutrient agar, these varieties of staphylococci differ from one another in the color of the resulting growth, aureus being a golden yellow, citreus a citron yellow, and albus milk-white. It is to be observed, however, that sometimes the color is slow in appearing in the citreus and aureus, so that they may at first be mistaken for albus. With respect to the behavior in gelatin, all three organisms produce liquefaction

though this is said to occur somewhat more slowly in the citreus than in the other two. Plates of these organisms as they grow on slanting agar appear facing page 28. Staphylococcus pyogenes aureus is probably the most common of the pus organisms. It occurs in abscesses and furuncles, in empyema, in the metastatic abscesses of so-called pyemia, in osteomyelitis, and in suppurative processes in general. So constantly is it associated with osteomyelitis that it has been called the staphylococcus of osteomyelitis. Numerous experiments have been performed with pure cultures of this organism, and inoculations in the human subject have been uniformly followed by suppuration. Pure cultures have been simply rubbed into the uninjured skin and have resulted in a crop of abscesses or furuncles. Osteomyelitis has likewise been produced in animals by injecting the organism into the circulation and then fracturing a bone.

Less common and perhaps less pathogenic are the citreus and the albus. The citreus has been recovered from postmortem wounds in pure culture and occurs in suppurative processes in general, but less frequently than the aureus. The albus has likewise been found to occur in abscesses, but it is more commonly found associated with other organisms than alone. It is, however, capable of exciting suppurative processes in pure culture, but it is not so virulent as the aureus. With regard to Staphylococcus epidermidis albus, Professor Welch has shown that this is a constant inhabitant of the epidermis, occurring in the follicles and the deeper layers of the skin. It is not, therefore, easily reached by antiseptics. Its pathogenic power, fortunately, is feeble, but it is the most common cause of "stitch abscess," and is, therefore, of special interest to the surgeon.

Some observers have supposed that this organism is identical with the ordinary white staphylococcus, or is merely an attenuated form of the latter, which supposition seems not improbable.

Streptococcus pyogenes.—Streptococcus pyogenes is an organism which is of paramount importance to the operating surgeon. It is, if anything, even commoner than the golden staphylococcus. It occurs on the hair and on the cutaneous and mucous surfaces, but especially on the latter, particularly in the mouth. It is now generally accepted as the cause of erysipelas, but it is found in suppurating wounds which are not markedly erysipelatous, though in such cases there is frequently observed a faint blush about the edges of the wound. In erysipelatous wounds it may be recovered from the red margin of the advancing inflammation by puncture and subsequent inoculation. It is nonchromogenic and nonliquefying, in this latter respect differing from the three first described staphylococci. It may be recognized under the microscope as growing in chains and not in groups. It has given rise to erysipelatous inflammations when inoculated in the human subject, as well as when inoculated in animals. It is also the cause of puerperal fever.

Bacillus pyogenes soli was discovered by Bolton in 1892 during his experiments with tetanus at the Hoagland Laboratory. It is found in the soil and in pure cultures, and occurs as irregularly shaped short rods, sometimes swollen at the ends; these stain irregularly. It is a facultative anaerobe, does not liquefy gelatin, and is nonmotile. It does not grow well in agar, but best in gelatin which is slightly acid. Data are wanting in regard to its pathogenesis in man. In a case admitted to St. Mary's Hospital it was recovered

in pure culture from an extensive phlegmon of the calf occurring after an abrasion of the skin about the Achilles tendon, into which much earth had been ground.

Bacillus pyocyaneus (Plate I, Fig. 2) is a slender bacillus with rounded ends, occurring in pairs and also in chains of four or more cells. It is both liquefying and motile and possesses the curious faculty of imparting a peculiar bluish-green color to agar or gelatin. This coloration is diffused through the medium and is not confined to the growth itself. It is a transparent and somewhat fluorescent color. From this the bacillus gets its name, pyocyaneus, or the bacillus of green pus, to which it imparts the greenish color. In three cases occurring in my service in St. Mary's Hospital, in which it was found in pure culture, there was present a progressive and rapid gangrene.

The diplococcus of gonorrhea (the gonococcus of Neisser) (Plate I, Fig. 4), though not usually associated with wounds, is nevertheless a pus-producer. It is probable that the cases of suppurative adenitis and acute prostatitis which sometimes accompany a gonorrhea are due to infection by this organism. The virulent and destructive ophthalmia which follows its introduction into the eye is too well known to need comment.

The affection described as gonorrheal rheumatism has been ascribed to the diplococcus of gonorrhea, though the latter cannot always be identified. Some writers deny that it is the cause, and, indeed, with regard to the so-called metastatic inflammations of gonorrhea, the adenitis and prostatitis, they assert that these sequels are due to an infection by the golden staphylococcus of suppuration. The following case occurred in 1890 in the practice of A. T. Bristow: A young gentleman consulted him with an angry looking pimple just below the patella. In two or three days this developed into a suppurative bursitis. Examination of the pus microscopically showed numerous diplococci present in the pus-cells, but no other organisms. These were identified by Bolton as the diplococci of gonorrhea. The patient then admitted the existence of the gonorrhea. He had evidently inoculated a mosquito bite with the organism, which in turn had infected the neighboring bursa. Certainly it does not seem unreasonable to suppose *a priori* that an organism which is capable of exciting so virulent an inflammation as gonorrheal ophthalmia should also be competent to cause the complications, suppurative and nonsuppurative, which so often follow gonorrhea. It has never been shown that these complications follow suppurative urethritis caused by one of the other pyogenic organisms (pseudo-gonorrhea). In the case mentioned, this diplococcus and no other organism was recovered from the pus, the patient's condition being unknown to his surgeon.

The diplococcus of gonorrhea, or, as it is most commonly called, the gonococcus, is a micrococcus which occurs in pairs, sometimes in tetrads, division taking place in each plane alternately. The opposed sides of the cocci are slightly concave, so that they have been described as biscuit-shaped. The gonococcus is found only in the pus-cells themselves, and as there are several other organisms which resemble it in form, some being found even in the pus-cell, the following points of differential diagnosis must be borne in mind: (1) The gonococcus does not take the Gram stain, *i. e.*, it gives up the color in the decolorizing solution; (2) it refuses to grow on ordinary media, growing with some difficulty on blood-serum, preferably human blood-serum. Therefore, if an organism

PLATE I

Fig.1.

Fig.2.

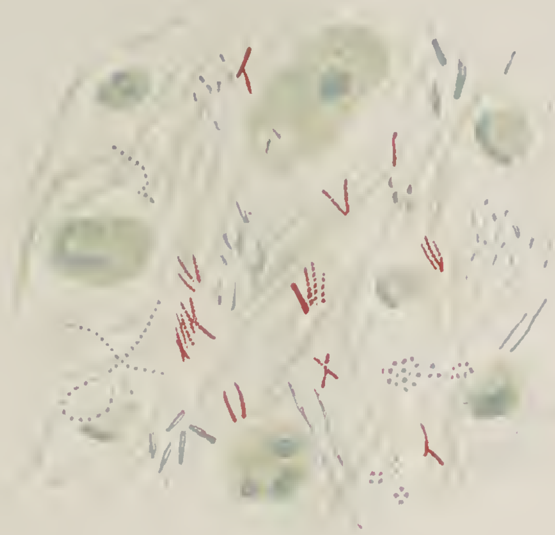


Fig.3.

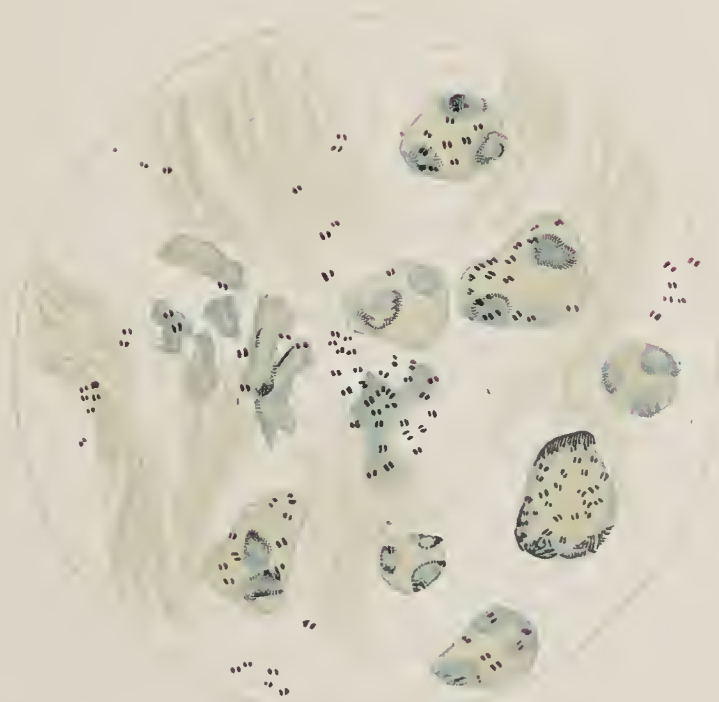


Fig.4.

FIG. 1. BACILLUS PRODIGIOSUS, AGAR CULTURE.
FIG. 2. BACILLUS PYOCYANEUS, AGAR CULTURE.
FIG. 3. TUBERCULOUS SPUTUM.
FIG. 4. GONOCOCCI, ENCLOSED IN PUS CORPUSCLES.

resembling the gonococcus takes the Gram stain, or if it can be grown on the ordinary media, it is not the specific organism of gonorrhea, even though it resembles the gonococcus in other particulars.

The gonococcus stains somewhat slowly with the Löffler stain; more readily with the methyl-violet solution of the Gram stain.

Specific Pathogenic Bacteria.—Lustgarten and others have claimed that syphilis is a bacterial disease, and different organisms have been described in this connection, but at present the matter is not sufficiently well settled to deserve more than passing notice in this place. So, too, with chancroid; as yet no definite organism has been associated with either the sore itself or the resulting bubo. It seems probable, however, that in all these diseases bacterial infection plays an important part.

Diphtheria may occur in wounds, and, as the surgeon is sometimes called upon to perform tracheotomy in the course of the disease, a brief description of the organism may not be out of place. The organism is a bacillus known as the **Klebs-Löffler bacillus,** Klebs having discovered it in diphtheritic membrane, its identification with the disease being completed by Löffler. Its morphology is somewhat peculiar. It is sometimes quite straight, sometimes curved, and in a single cover-glass preparation both forms may be seen; some are swollen at the ends, some in the middle. Often it stains irregularly. It does not form spores, nor are the rods ever seen in threads. It stains well with the Löffler methylene-blue. With regard to its behavior in culture-media, it is aerobic, nonmotile, and nonliquefying.

The Bacillus of Tetanus.—One of the most important of wound diseases with which the surgeon is confronted is tetanus, though its importance is derived rather from its fatal character than from the frequency with which it occurs. Formerly this disease was attributed to wounds of nerve structures, but the researches of Nicolaier, Kitasato, and others have shown that it depends on a peculiar bacillus called, from its discoverer, the bacillus of Nicolaier.

This organism is a rather slender rod, usually bearing a single spore at one end, so that the bacillus and spore resemble a drumstick. In pure cultures not only the drumstick, but separate spores also are found.

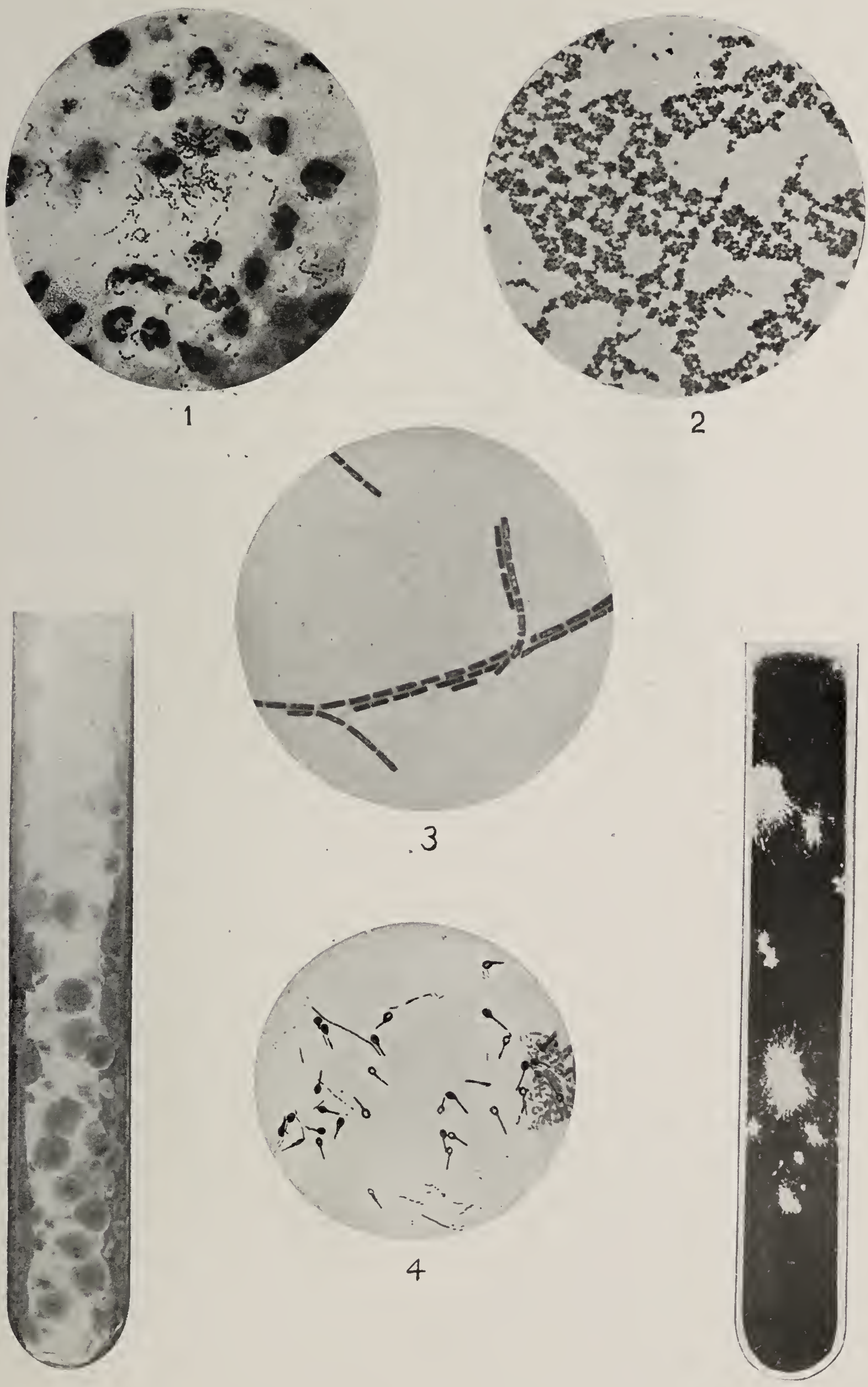
This bacillus is a very strict anaerobe and must be cultivated in an atmosphere from which oxygen is excluded. For the surgeon a convenient method of accomplishing this is as follows: Nutrient agar in a test-tube is melted and allowed to cool to 80° C. (176° F.). It is then inoculated in the usual manner with the secretion of the wound and kept at 80° C. for the space of twenty minutes. This temperature kills the other organisms which may be present, but does not affect the spore of tetanus, because of its high power of resistance. The agar is then allowed to cool, and after it has set, the remainder of the tube to within a short distance of the cotton plug is filled with liquid agar. This thick layer of superincumbent agar prevents the oxygen from gaining access to the inoculated layer at the bottom of the tube, in which the tetanus bacilli then develop in about forty-eight hours if placed in the incubator. The colonies have a peculiar shape as they grow, sending out long fuzzy prolongations from the parent colony, as represented in Plate II, Fig. 5. They never grow very near the surface of the agar. When cultivated in gelatin, the tetanus bacillus slowly liquefies the medium. It is a gas-producer to a limited

extent, and motile. This organism is not found in the blood nor in tissues remote from the wound. It must be recovered from the wound itself or from the immediate vicinity. Cultures exposed to diffused daylight soon lose their pathogenic power. This may account for the fact that some observers have failed to produce the symptoms of tetanus in animals by cultures not kept in the dark. The nervous symptoms of tetanus owe their origin to two extremely poisonous alkaloids, called tetanin and tetanotoxin, either of which when injected into susceptible animals causes the symptoms characteristic of the disease. Besides these alkaloids, a toxalbumin has been isolated which is said to be still more poisonous. Some observers have claimed that the poisonous product of the tetanus bacillus is of the nature of a ferment.

The Anthrax Bacillus.—This organism is of special interest to bacteriologists because it was the first organism that was conclusively shown to be pathogenic. Koch demonstrated the relation between the anthrax bacillus and the disease of cattle called splenic fever by inoculating animals with pure cultures of the bacillus. Never before had any organism been grown on artificial media, and it was from this time that the science of bacteriology began to have a firm basis. The anthrax bacillus is of interest to the surgeon because it produces in man the gangrenous spreading ulcer called malignant pustule. It is a rather long bacillus, with squarely cut ends, is rarely seen isolated, but grows for the most part in long threads, usually twisted together in convolutions. It is a spore-producer when in contact with oxygen, is nonmotile, aerobic, and slowly liquefies gelatin. In a long stab in gelatin or agar, the organism grows to the end of the stab, but more abundantly as it approaches the surface, sending out fuzzy prolongations sideways which are most abundant at the top of the stab and hardly visible at the bottom. In this respect it is the opposite of the tetanus bacillus, in which the reverse is true. The gelatin first commences to liquefy at the top, as shown in Plate II, Fig. 5. In Plate II, Fig. 4, are shown the rods, some undergoing spore formation. This does not occur, it is to be remarked, in the living body, therefore in a cover-glass preparation of a suspected malignant pustule only the rods will be seen, never the spores. They resemble very closely the rods of the hay bacillus, which is, however, motile. To observe this distinction it is necessary that the preparation should be examined unstained and unflamed. The organism of malignant edema somewhat resembles the anthrax bacillus, but is motile and a strict anaerobe, and may thus be distinguished by cultivation. It is not likely to be met with, however, and has not been described among the organisms of wounds because its pathogenic power in man seems doubtful. All these organisms stain readily with Löffler's stain.

Bacillus tuberculosis (Plate I, Fig. 3).—In 1882 this organism was proved by Koch to be the specific cause of tuberculosis. It is found in the sputum of tuberculous patients, in tuberculous glands, in caries and in those joint affections which are the result of tuberculous infection. It has also been shown to exist in great numbers in the diseased tissues in cases of lupus. This organism is a strict parasite and exists in the form of very fine rods, usually curved, with rounded ends. The organism stains with great difficulty, but when stained retains the color, resisting for some time the decolorizing agency of alcohol and nitric acid. The directions for staining have already been given in a previous part of this section. When thus stained, all other organisms having

PLATE II



1. Streptococcus Pyogenes.
2. Staphylococcus Pyogenes Aureus.
3. Bacillus Anthracis.
4. Bacillus Tetani.
5. Stroke Culture of Tetanus.
6. Culture of Malignant Edema.

been decolorized by the action of the alcohol and nitric acid, the tubercle bacilli are seen as very small and slender red rods, with empty or unstained spaces in individual rods. These unstained spaces have been called spores by some writers, but spore-formation has not as yet been shown to exist in connection with the tubercle bacillus. The rods are extremely fine and slender, so that it takes some little practice to see them. They do not grow on ordinary gelatin or agar, but grow readily on glycerin agar in the incubator, not, however, at the room-temperature. The organism can be best obtained in pure culture from a nodule in a case of tuberculous meningitis or peritonitis, care being taken to avoid contaminating the cultures with surface organisms. If the peritoneum is used, the abdominal wall having first been opened to the transversalis fascia, the opening into the peritoneum should be made with a sterile knife and with appropriate precaution. A tubercle is then removed from the peritoneum, crushed on a sterile surface, and implanted on a slanting glycerin-agar tube. If contamination has not occurred, no growth will be apparent until the lapse of two weeks, when fine grayish-white points will be seen growing at intervals from the inoculated surface. These slowly increase until the surface of the agar is covered with a dry yellowish-white growth, looking very much like bread-crumbs, scattered over the agar. As it is necessary to keep the tubes in the incubator for so long a period, either they must be sealed above the cotton plug with sealing-wax, or the air of the incubator must be kept moist by a vessel of water within. It is not always easy to discover tubercle bacilli in tuberculous joints. As many as twenty sections were made before the bacilli were discovered by one observer. Roswell Park, however, in a series of observations lasting over two years, was almost always able to find them. If not readily found with the microscope, the internal surface of the thigh of a guinea-pig or the anterior chamber of the eye of a rabbit may be inoculated with a bit of the tuberculous material from the joint. In about six weeks the animal will die of tuberculous infection. Unfortunate examples of autoinfection have followed operations for the relief of tuberculous affections. A. T. Bristow has observed two cases where tubercular nodules of the skin followed slight punctures in the course of operations on tuberculous patients. In a case where puncture of a joint of the thumb resulted in tuberculous synovitis, subsequent general infection followed and death occurred in a year and a half.

A bacillus occurs about the genitalia which has been named the **smegma bacillus,** and which bears a remarkable resemblance to the tubercle bacillus. It may occur in urine which is being examined for the tubercle bacillus and give rise to an erroneous diagnosis. The inoculation test would, of course, settle the question beyond a doubt.

The Lepra Bacillus.—Leprosy is a disease which is but seldom seen in our northern latitude, though on account of importation, cases are more common now than formerly. The organism of leprosy, the so-called lepra bacillus, very closely resembles that of tuberculosis, in regard to size, general appearance, and behavior when brought in contact with decolorizing agents. It is, however, somewhat smaller than the tubercle bacillus, with more pointed ends. It stains more easily than the bacillus of tuberculosis, but gives up its stain with the same difficulty. For purposes of staining the same solutions may be used as with tubercle. This organism has never been successfully cultivated on artificial media. Its causal relation to leprosy has been definitely ascertained.

The Bacillus of Glanders.—Glanders, while primarily a disease peculiar to the equine race, nevertheless is not infrequently communicated from diseased animals to man. It is the result of the infection of the animal by the bacillus of glanders (Löffler and Schütz, 1882). This organism, too, bears some resemblance to the tubercle bacillus, but is shorter and thicker. It stains with some difficulty, but easily parts with its stain in decolorizing fluids. It stains most readily in a hot solution of Löffler's alkaline blue, and grows fairly well on all media, best perhaps on glycerin agar. It is aerobic, nonmotile, and does not liquefy. Pure cultures of this organism may be obtained, if proper precautions are taken, from the interior of the so-called farcy buds or nodules.

NON-BACTERIAL SUPPURATION

Foreign bodies buried in the tissues, as well as mechanic and chemic irritation, have long been looked upon by surgeons as causes of suppuration. After Lister's demonstration of the germ origin of wound suppuration, however, many referred suppurative processes to the direct intervention of bacteria. Some, nevertheless, held that, while microorganisms were the accompaniment of suppuration, they were not necessarily the cause of it.

Experiments conducted with the view of settling the question were contradictory and misleading until, as familiarity with proper methods of technic increased, common sources of error were eliminated. These consisted principally in attempts to cause suppuration by the introduction into the tissues of such substances as croton oil, mercury, and turpentin. The different results obtained by different observers were in part due to the fact that the injected animals used in the experiments did not always belong to the same species. Some animals are peculiarly susceptible to suppurative and analogous processes, while others possess a comparative immunity from them. Turpentin, for instance, will produce these in dogs but not in guinea-pigs. By far the most common and serious sources of error, however, arose from faulty aseptic technic.

Experiments serving to show that suppuration could be caused by heat-sterilized pus, which presumably contained only the chemic products of pus organisms, were reported in 1878 (Pasteur). These were confirmed in 1885 (Petrour), the animals used being rabbits and guinea-pigs. Bouillon cultures of Staphylococcus pyogenes aureus, after being both heat-sterilized and filtered, produced suppuration (Christmas). The same results were obtained from injections of croton oil in the cellular tissues beneath the skins of rabbits (Councilman). Experiments conducted along the same line, with the precaution, however, of placing the croton oil in hermetically sealed sterilized glass tubes introduced beneath the skin of the animals and broken at different intervals of time after the wounds had healed, gave different results. In no case was real pus produced, but only a mass of puslike consistency. This is to be regarded as one of the changes that take place in fibrinous exudations as the result of the solvent action of living cells on tissues destroyed by the action of the chemic irritant (Cheyne). In this connection attention may be called to the property which chemic substances possess of attracting or repelling certain kinds of organisms (**chemo-**

taxis). In the case of the chemic substances placed beneath the skin, both these and the resulting dead tissue exert a similar chemotactic action and attract the leukocytes.

The introduction of calomel will almost invariably produce a puslike material, which, however, differs in several particulars from true pus: the cell nuclei are single, cystic, and stain only feebly (Steinhaus). Finally, the products of decomposition produced by bacteria, as well as the ptomains of putrefaction, such as cadaverin, may produce pseudo-suppuration.

Aseptic suppurative processes, or suppurative inflammation without the presence of bacteria, to which reference has been made, and with which the results of irritation with jequirity seed (Baumgarten) are to be classed, require further investigation and study. The fact, however, that they are germ-free is of interest to the surgeon, and with more extended knowledge of laboratory methods he will be able to distinguish between these and suppurative inflammatory processes which depend on bacterial infection (see Surgical Bacteriology).

GENERAL DIAGNOSIS OF INFLAMMATION

Objective Symptoms.—The classic objective symptoms, namely, redness, heat, and swelling, are usually perceptible, the first to the sense of vision (inspection), the second to touch (palpation), assisted by thermometric instruments, and the third to vision and touch.

Inspection.—When the inflammation is deep-seated or but slightly developed superficially, inspection may not reveal the presence of redness. Swelling may also escape observation, particularly if the point of inflammation is covered by thick fascia. The redness of inflammation is to be differentiated from that produced by mechanic obstruction. The swelling may likewise prove a source of error in cases where it is due to the presence of a tumor. Here, however, the redness is of a bluish tint, and in cases of long duration the superficial vessels are more or less dilated. The redness of acute inflammation is evenly diffused, of rather light color, and without any appearance of ramifying vessels. Changes in color may be observed. Subcutaneous rupture of vessels and effusions of blood into the tissues, together with the subsequent breaking down of the red blood-corpuscles of the effusion, cause a staining of the tissues by the blood-pigment. This, combining with the inflammatory redness, produces the peculiar tints of yellowish blue, bluish green, or even deep brown.

In addition to the redness and swelling, inspection sometimes reveals the presence of pulsation, of blebs or bullae, of points of sphacelus, and of foreign bodies, facts which are of diagnostic value. Inspection of corresponding healthy portions of the body should always be made, when possible, for purposes of comparison. In this manner slight departures from the normal which otherwise might have escaped notice are made apparent.

Palpation.—When employed in the diagnosis of inflammation, palpation, as a rule, has for its primary object the discovery of that cardinal symptom of inflammation, elevation of local temperature. Exclusive of the so-called cold abscesses, the symptom is rarely so slightly pronounced as not to be distinguished by the hand of the surgeon applied to the skin at the point of

inflammation. It is comparatively a rare circumstance, in acute and subacute inflammatory foci, that the local elevation of temperature is not sufficiently great to permit of a diagnosis on the strength of this symptom alone. The dorsal surface of the fingers of the examiner should be employed rather than the palmar, the latter, in doubtful cases, being nonsensitive to slight changes of temperature. Here a comparion of the point under examination with the corresponding healthy portion of the body will often prove of value.

Palpation is further employed to determine the presence or absence of **fluctuation.** This symptom depends on the presence of fluid at the point of inflammation, either serous or suppurative. It is based on that physical property of all fluids by reason of which they produce wavelike movements in the mass when disturbed, and thus transmit the sense of pressure from one side to the other. In the case of large accumulations, as, for instance, serous effusion within the peritoneal cavity, the wave can be distinguished by sight as well as by touch, especially if the abdominal walls are thin. Fluid which occurs within inflammatory foci, however, is, as a rule, so covered by tense and unyielding tissues that these wavelike movements cannot be produced. Under such circumstances advantage is taken of another physical property of fluid, that of propagating pressure equally in all directions. The finger being placed on each side of the swelling, alternate pressure will convey the sense of transmitted motion, always to the passive finger, no matter in which axis of the tumor the fingers are placed. In estimating the importance of this symptom in any given case the surgeon should not fail to appreciate the character of the tissues overlying the site of the supposed fluctuation. This is of special importance where large muscular masses, such as the quadriceps extensor of the thigh, intervene, most of the sensation which otherwise would be conveyed to the touch being lost, unless both fingers are firmly pressed deep into the tissues. The right index-finger may be placed at the margin of the suspected swelling and steady pressure made in such a manner as to increase the tension within the cavity containing the fluid. Pressure made at some other point of the swelling with the left index-finger will lift the other finger to the same extent to which the fluid is displaced. Should the right index-finger remain stationary or fail to feel the pressure when it is but slightly made by the left, then the pressure is not propagated by fluid and the examination is negative.

All collections of fluid within the body cannot be demonstrated by means of palpation. This is true of accumulations of pus within cavities bounded by bony walls. Not only may cavities with rigid walls be situated in bone, but those having originally soft and yielding walls may become changed by inflammatory processes or long-continued pressure, so that the finger fails to make any impression. This is most likely to occur where collections of inflammatory fluid become encysted. Subfascial phlegmons of an acute character also do not, as a rule, give rise to the sense of fluctuation on palpation, but rather appear to be a solid infiltration, until they find their way through the fascia, when a very distinct sense of fluctuation may exist at the opening, which also may be plainly felt. It frequently happens that fluctuation is felt when no fluid is present. This is called pseudo-fluctuation, and it depends on the failure to recognize the distinction between true fluctuation and elastic resistance. Faulty palpation is responsible for this error, which may be avoided

by strict adherence to the proper method of conducting the examination. The sense of fluctuation conveyed by muscular tissue when largely developed is such as to deceive at times the most careful observer.

So difficult is it to distinguish between the fluctuation of muscle and that found in collections of fluid in some situations, such as the thigh or the thenar eminences, that the result of an examination for fluctuation in these regions may be almost without value. Muscular fluctuation, however, it may be observed, always takes place **across** the axis of the muscle, never in the direction of the axis. Thus, if one index-finger is placed on the outer margin of the quadriceps extensor and the other on the inner margin, a very distinct sense of fluctuation may be produced which is caused by the rolling of the fibers of the muscle on their axes. If, however, one finger is placed on the center line of the muscle belly and the other above or below, *on the same line*, so that the motion, if any, will follow the axis of the muscle, muscular fluctuation never takes place, as the fibers are unable to roll against each other as in the other case.

Finally, certain solid tumors may simulate fluctuation. Of these, myxomas and sarcomas are to be particularly mentioned. These either contain in their tissues large amounts of nutrient fluid, or are peculiarly rich in cellular elements or cystic formations. The history of the condition, together with the presence of some of the other signs of inflammation, will assist in the diagnosis.

Palpation is further employed to determine how far the swelling extends and whether or not it is movable on the deeper parts (muscle, fascia, bone); in other words, its relation to surrounding parts. This point is specially important in establishing the differential diagnosis between an inflammatory swelling and the formation of a tumor. If the swelling, whether inflammatory or neoplastic, is in the neighborhood of a large vessel, the pulsations of the artery will be conveyed to the finger with more or less distinctness and may be visible to the eye. This is found to the greatest extent in aneurisms. Tumors with fluid contents, however, in the vicinity of large arteries transmit the arterial impulse very distinctly, provided there is much tension in the cyst or sac. Tumors of a soft or compressible character transmit pulsation less readily. Certain growths, such, for instance, as some of the sarcomas, in which large nutrient vessels have developed also exhibit pulsation, even at a considerable distance from large trunks. Pulsation is also present in the brain when its bony incasement is removed, and may occasionally be detected in the medullary cavity of large bones.

Friction sensations or sounds, as they are sometimes called, are conveyed through the palpating finger of the surgeon. These may follow injuries of different kinds, but are specially noticed in cases in which considerable blood is extravasated and coagulated in the connective-tissue spaces. There is also a peculiar crepitating feeling conveyed in cases in which serum is forced through elastic effused material. In serofibrinous exudations in synovial cavities, particularly where the walls of the latter are covered by a proliferation of tissue, these sensations of friction are also felt.

The sense of hearing is not often employed by the surgeon for diagnostic purposes in inflammatory conditions. In instances in which there is a question of differential diagnosis of inflammatory conditions and aneurismal tumors, the stethoscope is employed. The conditions which produce the sensation of

friction above alluded to also produce audible friction sounds, but for the detection of these, even when aided by the stethoscope and its modifications, the sense of hearing is rarely useful.

The sense of smell is likewise employed for diagnostic purposes in cases in which the odors are given off by gases having their origin in foci of putrefaction.

Instrumental aids to diagnosis have long been employed by surgeons. First among them is the **probe.** This little instrument is intended to serve as a prolongation of the finger, and gives information to the surgeon of the condition of structures which communicate with the air through either natural or artificial channels, but which, by reason either of the narrowness of the channel or of its depth, are inaccessible to the touch. It is also used to determine the location and presence of foreign bodies, such as bullets, etc., and necrotic bone. In the treatment of old sinuses it is likewise useful to convey certain medicaments within its tract, such as stimulating applications, caustics, etc., or a tampon of medicated gauze, or a drainage-tube.

Exploratory puncture is of special importance in the diagnosis of certain inflammatory conditions, and of their products. This is generally accomplished by means of the aspirator, though a deeply grooved needle called an exploring needle may often be used instead. By the use of this means the presence of liquids may be ascertained, together with their character. For diagnostic purposes the common hypodermic syringe may be used, the needle having been first sterilized by being passed through an alcohol lamp.

It sometimes becomes necessary to employ **mensuration** for the purpose of establishing and recording differences in the circumferences and lengths of parts.

As aids to inspection varieties of instruments are employed. Of these, the laryngoscope, the rhinoscope, the ophthalmoscope, and the endoscope are examples. An important aid to diagnosis of which surgeons of the present day avail themselves much more frequently than did those of former times is the microscope. Its aid is constantly invoked to determine the nature of the products of disease, the malignancy or benignancy of neoplasms, and to assist in identifying the various bacteria of wound diseases. Finally, the thermometer and the sphygmograph are employed in estimating the extent of the participation of the entire organism in the inflammatory process. The thermometer measures the variation of animal heat, the sphygmograph the changes in vascular tension. (For Laboratory Aids to Diagnosis see page 243.)

Fever.—In every acute inflammation, whether exudative or suppurative, more or less constitutional disturbances arise. Of these, the most important to the surgeon is fever. This scarcely ever commences earlier than twenty-four hours after the reception of the injury, is coincident with the beginning of putrefactive changes in the blood and the secretions in and about the wound, and pursues a course parallel to these changes, rising or falling according as these processes are rapid and extensive or the reverse. If the latter are moderate in degree and extent, there may be simply a morning and an evening rise of temperature, with subsequent remissions. The occurrence of a sudden chill followed by a considerable rise of temperature (103° F. or more) always indicates a profound degree of intoxication through influences more pronounced than those which produced the original fever.

Coincidentally with the rise of temperature there occurs an increase in the

frequency and force of the pulse, as well as an acceleration of the respirations. There is a more constant relation between the temperature and the pulse, however, than between either of these and the respiration.

The usual and typic symptoms of anorexia, impaired digestion, etc., occurring in other forms of fever, likewise exist in surgical fever. The aversion to meat is particularly noticeable. Even liquid food is taken but sparingly, as the digestion is much weakened, if not interrupted altogether. The urine is of a dark wine-color, due to the presence of urates in large quantities, and usually the daily quantity falls below the normal. While the total quantity of urine may be decreased, there is nevertheless an increase in the amount of phosphates, urates, and particularly the potassium salts and urea, which indicates an increased metamorphosis and waste of tissue. The albuminates and their derivatives eliminated are derived from the tissues themselves. This to a certain extent explains the emaciation of fever patients. During this time the subjective symptoms are well marked. Thirst is excessive, restlessness is very great, and there may be delirium. With the occurrence of profuse suppuration from the wound, these symptoms gradually subside if the outpoured pus contains but few of the products of putrefaction (laudable pus of the ancients). On the third or fourth day the discharge of pus is well established, granulations spring up, and the wound is said to "clean off." At the end of about a week the temperature falls to normal, the tongue clears, moisture replaces the unnatural dryness of the skin, and convalescence is established.

Subjective Symptoms.—In establishing the diagnosis in any given case too much reliance should not be placed on the patient's history as given by himself. In fact, the more the surgeon relies on the objective symptoms to the exclusion of the subjective ones, the less frequently will he be in error. This arises from the fact that patients are apt to exaggerate the importance of some symptoms and to belittle others, if not to conceal them altogether, as in affections of venereal origin. At the same time we cannot entirely ignore the patient's statements, unless there is good reason to believe that he is a malingerer. If the case in hand is of traumatic origin, an account of the manner in which the injury was received will always be in order. Long voluntary statements should even here be discouraged as far as possible, and this portion of the examination should take the form of question and answer. Under other circumstances, where the case is of a more chronic character, only the bare statement from the patient as to the part affected should be received, after which the examination should be categorical and physical. The form of the inquiry should be based on what the surgeon sees or feels when the affected part is presented to him. In general the age, occupation, and condition in life, whether married or single, are useful points with which to commence. Then follows an inquiry as to the time at which the patient first noticed the impairment of health. After this the symptom or group of symptoms which first attracted the patient's attention is inquired into Then comes the question as to the persistence or abatement of the symptoms and the occurrence of new ones. The patient should thus be carried through the course of the disease until the present time is reached. A series of short and sharp inquiries, made somewhat after the manner of an examining attorney addressing a witness, without waste of words or time, and directly to the point, may throw considerable light on the case. Under no circumstances should the patient

be permitted to go into long and tedious details, and when disposed to do so he must be brought back to the proper point in the examination by a well-directed question. The main points bearing on the case must be borne in mind, the patient being permitted to volunteer but very little, and the surgeon asking as few questions as possible. The tact and knowledge necessary to carry on an examination of this kind can be obtained only at the patient's bedside or in the clinic. Fixed rules, though they are of great service, cannot be made for application to all cases. The beginner will be compelled rapidly to run over in his mind what the condition before him *may be*, and, having grouped together all points, he will proceed to determine what it *is*. Knowledge of all the branches of medical science is of use to the surgical practitioner, and the information gained in the autopsy room is of the greatest possible value.

In taking into account subjective symptoms, particularly that of **pain,** the surgeon will be careful not to give undue consideration to them. If careful examination does not reveal any good and sufficient reason for the existence or the persistence of pain, the case should be carefully watched for objective corroborative symptoms or for simulation. If the patient is a plaintiff-at-law, the surgeon will find it necessary to be more than ever on his guard. The same remarks apply to local points of tenderness. The surgeon should always, in doubtful cases, after a patient has complained of a point of tenderness, endeavor to verify or to disprove its existence by distracting his attention from the point complained of, and then, without the patient's knowledge, applying as nearly as possible the same amount of pressure as before.

Loss or impairment of function may be present as a subjective symptom, or its presence may be objectively demonstrated by special means adapted to that purpose, *e. g.*, electricity, in loss of function of muscles. The loss will manifest itself in various ways, according to the part affected. A glandular structure may cease to furnish its normal secretion. An impairment of the special senses may also be properly included in the subjective symptoms.

Finally, it should be borne in mind that but few diseases or inflammatory conditions have a merely local importance. The local inflammation, for instance, may give rise to a general disturbance, as in traumatic fever, and *vice versa*, as in general tuberculosis.

TERMINATION AND PROGNOSIS OF INFLAMMATION

Inflammation may terminate (1) in resolution; (2) by healing and cicatrization; (3) in death. Termination by resolution takes place in the majority of cases of serous inflammation. The effused fluids undergo but slight changes, unless infection occurs, and are soon taken up by the lymphatics, the normal condition of the tissues being then restored. In cases in which healing by the formation of cicatricial tissue occurs, the course is that followed by all suppurative and some granulating forms of inflammation. In discussing the second manner of termination of inflammation it was formerly the custom to speak of it as terminating in suppuration. That this is illogical may be seen at a glance, because the suppuration does not terminate the process at all, but is simply an incident in its course. Both suppurative and gangrenous inflammation, after greater or lesser loss of tissue, proceed to cicatrization in a comparatively short time. In cases of granulating inflammation, however, the

repair proceeds much more slowly, and a tendency to recurrence is manifested. The granulating tissue is destroyed as rapidly as formed under the influence of the pathogenic microorganisms. When healthy granulations form, cicatrization may take place, the bacteria being prevented from coming in contact with sufficient pabulum on which to subsist, and hence perishing. When caseation takes place, a healing reparative process is impossible. It sometimes happens that, within the area of a granulating inflammation, the organisms of suppuration penetrate, and an acute or a subacute suppurative process intervenes. The formation of pus leads to destruction of the diseased granulating tissue, the pus finds its way to the surface or is evacuated, and cicatrization occurs. The originally infecting pathogenic bacteria seem to be destroyed in the process.

Whether lymphatic resorption of pus ever occurs, or granulating inflammation undergoes repair without leaving cicatricial tissue behind, is uncertain.

Death occurring from the direct effects of the presence of inflammation is of comparatively rare occurrence. When this does occur, it is usually the result of the sloughing away of the walls of a large vessel, death taking place from acute anemia (hemorrhage). But death occurs frequently from the more remote effects of inflammation, or from its indirect results. In the great majority of cases in which a fatal result follows, it is through the medium of an infection from the seat of inflammation, which occasions a disturbance of the entire organism. A familiar example of this general infection is found in traumatic fever. Although this is not particularly threatening to life, yet it may become so in cases in which the vital resistance is lowered by large loss of blood, pre-existing disease, or old age. When the reception of a wound gives rise to a fatal result, the immediate effects of the trauma being excluded, death is due to the supervention of one or the other of the wound sequels, or wound diseases.

Granulating inflammation may prove fatal by infecting the entire body, as in miliary tuberculosis. Amyloid degeneration of the spleen, liver, kidneys, and blood-vessels of the intestinal canal may produce a fatal issue in a case of long-standing granulating inflammation of tuberculous origin. While our best efforts are directed toward saving life, the restoration of the function of the part which is the seat of inflammation is also entitled to some consideration. This will depend to a certain extent on the part affected. While muscular and glandular structures show, as far as their functions are concerned, but slight traces of inflammatory conditions, the same may not be said of the articulations. And these will, in turn, be profoundly disturbed in their functions according to the extent, duration, and character of the inflammation, as well as the particular joint attacked.

SURGICAL FEVER

In speaking of the participation of the entire organism in the inflammatory process mention has been made of fever. This is the most important of the constitutional symptoms of inflammation. In the study of surgical fever it will be necessary, in order properly to appreciate all of its phenomena, to inquire into the **physiologic regulation of the temperature of the body,** and the principal factors concerned in this regulation. Of these the most important

are (1) the reception of oxygen by the blood-corpuscles, and the subsequent process of oxidation which takes place in the tissues and blood; (2) the division of the appropriated nutrient materials into their final products of carbon dioxid, water, urates, urea, and the constituents of the bile; (3) the action of the muscles, when in a state of contraction as well as when at rest; (4) the action of the glands, in which, during the process of secretion, heat is set free; (5) the action of the central nervous system. The most important ways by which heat is lost to the body are (1) through the skin ; (2) through the exhaled air; (3) by the secretions and excretions which leave the body, notably the sweat, urine, and feces.

The blood is the balancing medium between production of heat and loss of heat. As the circulating fluid passes through the lungs it gives off a portion of its heat to the alveoli, and at the same time receives oxygen, which becomes a source of increased heat during the process of oxidation. Thence it passes through the systemic circulation, parting with a portion of its caloric in the capillaries of the skin, because of its proximity to the surrounding air. In the muscular system it is reinforced by the metamorphoses going on, only to part with the heat again at some other point. The blood therefore furnishes oxygen and nutrient material, the agents necessary for the active performance of the functions of the organs; and, in addition, it equalizes the warmth of the different organs, thus producing a uniform temperature. Inasmuch as the temperature of the surrounding atmosphere differs greatly under different circumstances, it becomes evident that a much greater loss from the body will take place at one time than at another. Though the temperature of the body will vary slightly under normal conditions, yet these variations are incomparably less than those which take place in its surroundings. It is therefore evident that there must exist some means within the body itself of preventing at one time too great a production of heat, and at another too great a loss. In other words, there must be some physiologic processes instituted for the purpose of regulating the temperature of the body.

The temperature of the body varies, within normal limits, between 98.3° F. and 99.2° F. Normal elevations of temperature are due to several circumstances, such as the reception of food, movements of the body, and particularly vigorous and long-continued muscular exertion. To compensate for variations of temperature in the surrounding air, loss of heat by conduction and radiation is to a certain extent limited. Increase of the temperature in the surrounding air, which otherwise would lead to diminution of the loss of heat from the living body, is balanced by a simultaneous dilatation of the arteries of the skin. This causes a much larger quantity of blood to flow to the surface and hence a larger quantity of caloric is parted with in a given time. The insensible perspiration, or transpiration, depending on increased flow of blood to the surface and an irritation of the sweat-glands, also tends to diminish the temperature by evaporation from the surface. Under certain conditions in which the atmosphere is charged with moisture accompanied by a high temperature (humidity), greater suffering is experienced by the individual for the reason that the moisture from the surface of the body is prevented from evaporating; on the other hand, a dry hot air is easily borne. Under the influence of surrounding heat the body is rendered unfit for exertion for the reason that all unnecessary movements are restrained in the instinc-

tive desire to prevent the production of more heat. When the surrounding air is cooler than the body, regulation of the temperature is accomplished by means of the contraction of the arterioles, whereby the amount of blood passing through the capillaries of the skin is lessened, and the loss of heat decreased. The impulse to increased muscular exertion is felt which, by furnishing an increased amount of heat to compensate for that which is lost, overcomes the sensation of cold experienced. Whether or not the lowering of the surrounding temperature leads to more rapid metamorphosis in the body when at rest, is an open question. Experiments on this point have given conflicting results; on the one hand, careful observation seemed to show that, under the influence of a lower temperature, increased elimination of carbon dioxid took place, and at the same time an increased appropriation of oxygen, while seemingly equally trustworthy experiments showed the reverse. As far as the increased elimination of carbon dioxid is concerned, a difficulty arises in that it is impossible to determine whether this is due to a more rapid metamorphosis and a consequent formation of this agent, or has its origin in a more rapid elimination of that which was already existing. Again, it has been shown that the quantity of carbon dioxid given off is not proportionate to the decrease of the surrounding temperature, and that the reception of oxygen and the elimination of carbon dioxid do not occur coincidentally with the rise and the fall of temperature. Liebermeister's observations in fever patients show that after cold baths there is a progressive fall in temperature for some time after the bath.

The nerves of the skin play an important part in the regulation of the body-temperature. The irritation of the surface of the body in consequence of changes of temperature external to the body induces reflex action along the paths of the vasomotor nerves. In addition, the existence of special heat-centers has been suggested, which regulate the production of body-heat. Fractures of the middle and lower cervical vertebrae and contusions of the spinal cord in this region have been followed by rapid and extreme rise of temperature. Experiments by Naumyer and Quincke on animals showed rapid rise of temperature after division of the spinal cord. This also follows separation of the medulla oblongata from the pons Varolii. I have seen it follow depressed fracture of the occipital bone with extensive laceration of the cerebellum. The latter observation suggests the presence of an inhibiting heat-center in the brain, while the former implies the presence in the cervical portion of the cord of inhibiting fibers from a center in the brain itself. Eulenburg and Brown-Séquard demonstrated on animals the fact that destruction of certain portions of the cortex cerebri resulted in a local rise of temperature, and. in addition, in a like effect on the muscles supplied from the centers destroyed. As the vasomotor nerves, both those which govern the constrictors and those which govern the dilators of the vessels, pursue almost the same course in the brain and spinal cord as the motor nerves, the effects obtained in these experiments, as well as in the case of contusions of the cord itself, may have been due to irritation or paralysis of these. Aronsohn and Sachs's (1884) experiments were instituted with the view of locating a heat-center near the corpus striatum. An increase of temperature followed the introduction of a needle at this point, in dogs and rabbits, but the same criticism will also apply to these experiments.

The existence, therefore, of either a heat-producing or an inhibitory center is not yet proved; according to our present knowledge, the vasomotor system of nerves alone serves to regulate the heat of the body.

The **febrile state** is undoubtedly brought about by a disturbance of the balance existing between the supply and the loss of heat as it exists in the normal condition. Whether a lessened loss, or an increased production, or both, constitute this disturbance, the effect is the same. An increase in the temperature of the body, as a whole, occurs, and a condition of **fever** results. As to the first of these propositions, *i. e.*, a lessened loss of heat, Traube advanced the theory that a reflex spasm of the constrictor muscular apparatus of the superficial circulation resulting from vasomotor disturbances produced a diminution of the amount of blood at this point, this necessarily leading to a diminished loss of heat from the skin, and causing the subjective sensation of chilliness and the objective rise in the temperature of the blood.

C. Hueter's theory somewhat resembled this, except that the latter attributed the narrowing of the lumina of the vessels to conditions existing in the blood, which lead to disturbances of function in circumscribed areas, the loss of heat in these being lessened, while in others an actual accumulation takes place. Hueter claimed that septic infection produced such changes in the blood itself that in these limited areas retardation or complete stasis took place, and that this was to be attributed to an adhesion of the white blood-corpuscles to the inner walls of the vessels, these blood-corpuscles containing micrococci, which cause obstruction to the blood-current. Isolated and grouped micrococci likewise appear adherent to the walls of the vessels, obstructing the passage of the red blood-corpuscles.

While it cannot be denied that in cases of pronounced or profound septic infection such conditions as Hueter describes may occur, yet it is scarcely probable that they are present in ordinary surgical fever. On the other hand, there would seem to be some foundation for Traube's theory that accumulation of heat within the body, resulting from contraction of the vessels of the skin, produces the general condition characteristic of the febrile state. For instance, during the stage of rigor, or even chill, the sensation of cold referred to the peripheral portions of the body is accompanied by a diminished loss of heat in the latter, and the objective symptom of rise of temperature. While this is apparently true of the initial stage of the febrile attack, it is likewise true that when the fever is once established the surface becomes actually hot, and gives rise to an increased elimination of heat. The thermometer placed in the axilla of a fever patient will rise more rapidly than one placed in the axilla of a healthy person. It should be borne in mind that, in surgical fever, at least in the majority of cases, the occurrence of an initial chill is either not marked or entirely wanting. Leyden has shown by calorimetric measurements carried on in patients suffering from remittent fever, that in the stage of fever there is actually a much larger amount of heat eliminated during the febrile stage than during the normal interval. These are confirmed by Liebermeister's experiments, and by Wahl, Senator, and others.

Neither Traube's theory nor Hueter's modification is sufficient to account for the indubitable fact that in the febrile state there is an **increased production of heat.** That this results from an **increased tissue**

metamorphosis there can now be but little doubt. Liebermeister and Leyden have both shown that the elimination of carbon dioxid with the exhaled air is much increased during the febrile state. The quantity increases in direct proportion to the rise of temperature, but the increased elimination ceases or subsides more rapidly than the temperature. This is in part accounted for by the fact that the respirations become more shallow when the fever is at its height. In addition to this, it has been demonstrated that an **increased amount of oxygen is consumed** in the febrile state, and that consequently an increased oxidation takes place. To this is to be attributed the presence of increased heat, which raises the temperature of the body.

Increased metamorphosis in fever patients is likewise shown by the greater quantity of urea eliminated, the increase of urea preceding the attack of fever. This would seem to suggest that decomposition of the albuminates takes place before the elevation of temperature, and that this decomposition is not the result but rather the cause of the fever. Other constituents of the urine are likewise increased. How far the formation and secretion of water are increased or diminished in fever can scarcely be determined by experiment, from the fact that water leaves the body through many channels. That which is separated by means of the kidneys is usually diminished, as well as that which is eliminated through the skin, as shown by the dry skin of fever patients. The amount of water eliminated by the lungs as well as the amount eliminated by the perspiration, particularly during the sweating state of the fever, is markedly increased, but this is compensated for by an increased production of water in the tissues. In the decomposition of nitrogenous as well as of nonnitrogenous substances water is formed by the addition of oxygen to the released hydrogen. An augmentation of these processes during the febrile state would therefore lead to the greater production of water.

This increased formation, however, does not apparently equal the demand on the part of the system for fluids to compensate for the loss occurring during the existence of the fever. Else how are we to account for the urgent thirst, the dry skin, the parched lips and tongue of fever patients? Lavoisier's view that the oxygen combining with hydrogen is derived for the greater part from the carbohydrates of the fat explains the rapid disappearance of the latter during the febrile state or under circumstances involving the occurrence of profuse sweating.

The relations existing between surgical fever and augmented metamorphosis are important, and deserve special consideration. The connection between the changes which occur in the wound and the patient's general condition is now well known. The most casual observer cannot fail to note that with the first occurrence of putrefaction in the wound, a rise of the general temperature takes place, and increases with the advance of an acute abscess, facts too well known to require more than casual mention here. These facts are suggestive of but one theory to account for their occurrence in connection with each other. The wound itself must contain the noxious agent which produces the rise of temperature, and this agent must be pyrogenic to the entire body.

The question as to the character of the agents which serve as etiologic factors in the production of surgical fever has long been a troublesome one.

Gaspard in 1882, and subsequently Magendie, Sédillot, and others, demonstrated that injection of putrid material under the skin or into the veins of animals invariably produced fever. Endeavors to isolate an active principle of a chemic nature from the putrid material were only partially successful (Bergmann's sepsin). A fresh impulse was given to the investigation when the rôle which microorganisms play in the production of wound infection was properly understood and their presence demonstrated in the blood itself. The action of the bacteria on organic substances was already known. It remained only to appreciate at its true value the fact that the infectious agents or toxic principles, the so-called ptomains, depend on the vital processes of these microorganisms.

Advanced methods in bacteriologic research and increased knowledge as to the pathogenic character of certain microorganisms have year by year confirmed the opinion that the presence of bacteria in the tissues or the blood itself, or in both, produces not only inflammation but also fever. At the present day it is generally held that the rise of temperature following the infliction of a wound depends on soluble poisons, the ptomains, which, acting as pyrogenic agents, exert a general influence on the body either through the nervous system or by way of the lymph-channels and blood-channels. These agents may exert their influence (1) by irritating the peripheral nerves, which in turn affect the central nervous system by reflex action; (2) by being taken up through the last-mentioned channels, passing into the general circulation, and being transferred thence into the tissues of the body, where by their presence an increased metamorphosis is excited.

It cannot be denied that such a thing as fever from reflex irritation may exist. Clinical observation supports this view. The condition known as **urethral fever** has been so classed. Even in these cases it must be admitted that the microorganisms which invariably inhabit the meatus urinarius may have been of a septic nature and may have been carried by the sterilized sound into the deeper parts of the urethra, there producing their appropriate phenomena. It is certain, however, that in the great majority of cases urethral fever can be prevented by the administration of a full dose of opium. It is also a clinical fact that the treatment of a stricture by gradual dilatation of the urethra will sometimes be followed by a chill subsequent to each introduction of the sound. But in the fever following wounds the course of the symptoms and the conditions present differ greatly from those mentioned above. In the case of wound fever the appearance of the fever is deferred for from twenty-four to forty-eight hours, while in the case of urethral fever the rise of temperature rapidly follows the passage of the sound. This makes it very improbable that the two conditions originate in the same way. It has been suggested, however, that the toxic material develops earlier in one case than in the other, but that in both its influence is exerted reflexly through peripheral nerve irritation. **Tetanus** has been cited as a wound disease which has its origin in a peripheral nerve disturbance. However, in the light of modern research and the work of Nicolaier, Kitasato, and others, tetanus has been shown to be due to a specific ptomain, the result of bacterial infection. Likewise if the nerve-trunks of a limb are resected, reflex disturbances being thus rendered impossible, suppuration artificially produced in the part deprived of innervation still produces all the phenomena of fever. On the other hand,

the injection of putrid material into the veins is invariably followed by similar febrile symptoms.

There can be no question but that the central nervous system is more or less disturbed in the febrile condition. This is evinced by the muscular trembling that occurs during a chill, and by the convulsive attack which is so frequently the precursor of a febrile attack in children. The cerebral disturbance, the psychic irritation, and the excessive sensibility are all the consequences of the introduction into the blood of the pyrogenic agent. That the vasomotor nerves participate more or less in this general disturbance is shown by the alternate flushing and pallor of the surface and the varying sensations of heat and cold. These latter symptoms, however, are rather a part of the general effects of the morbific agent and not a cause of the fever, since it has not yet been shown that the vasomotor disturbances result in an augmentation of tissue metamorphosis and increased heat-production.

It has already been stated that the muscles and glands are the chief sources of heat in the normal condition. Increased irritation of these structures was thought to be the source of the increased heat of fever. Becquerel, Helmholtz, Béclard, Ludwig Speiss, Heidenhain, and Körner, however, made a series of thermo-electric measurements in animals in which fever had been artificially produced, and demonstrated that even in inactive conditions of the muscles heat production is increased, as shown by an elevation of temperature in the adductor muscles and in the blood of the common iliac vein, as compared with that in the left heart. The same increased heat production is believed to take place in the glands. In the case of the muscles this is thought to be due to the so-called "insensible innervation" the result of the irritation, and in the case of the glands to the irritation of the nerves regulating secretion.

Neither direct irritation of the nerve-centers nor vasomotor disturbances are sufficient to account for the increased metamorphosis occurring in fever. As to the direct influence of the pyrogenic agent on the blood and tissues, there is during a febrile attack an evident increase in the coloring-matter of the urine, due to the augmented decomposition of the red blood-corpuscles. This destruction occurs to a still greater extent in highly septic conditions, and constitutes the so-called hematogenous icterus. The diminution of fibrin is likewise noticeable. Boeckmann demonstrated by actual count the relative diminution of the red blood-corpuscles during the fever stage of an intermittent fever, as compared with the number existing in the interval. Certainly no nerve interference can be said to be possible here.

What occurs in the blood without nerve influence can occur in the tissues to which the pyrogenic agent is conveyed by the circulation. The character of this agent, as well as that of the tissues with which it comes in contact, will govern in great measure the extent of the effect produced, just as specific phenomena are observed to follow the introduction of such soluble poisons as strychnin, curare, and ergotin in the muscular apparatus, and mercury in the glandular structures. The presence, on the one hand, of a ptomain or amorphous ferment in the blood and tissues, and, on the other, of the bacteria themselves, will determine the extent and character of the changes produced in the organism. As far as the bacteria themselves are concerned, these, cir-

culating in the blood, may accumulate in certain places, notably in the larger glandular organs, such as the kidneys, spleen, and liver, and also in the medullary structures of bones. The free supply of blood to these structures carries the microorganisms there in great numbers, where either the retardation of the blood-current or the presence of a terminal circulation causes their accumulation. Increased metamorphosis results from the irritation which their presence excites, and this, in turn, increases the production of heat. This fact explains the rise of temperature observed by Heidenhain and Körner in the common iliac vein.

Finally, the increased production of heat due to the inflammation itself is not to be lost sight of, for although it cannot alone explain the whole phenomena of fever, as suggested by Zimmermann and by most of the older writers, yet its co-operative influence is not to be denied. It is scarcely probable that the multiplication of cellular elements and the increased movements of the leukocytes can be accomplished without the production of increased heat.

Experimental research and clinical observation, therefore, justify the following definition: *Fever is an increased tissue metamorphosis, the essential result of the influence of pathogenic bacteria. This influence may be exerted directly by the presence of the microorganisms themselves, or indirectly by the products of decomposition and the presence of ptomains.* In addition, there are present irritations of the sensory and motor nerve-centers, particularly of the vasomotor nerves, the disturbances of which cause temporarily decreased elimination and increased irritability of the nerves of the vessels.

The Respiration and Pulse in Fever.—As fever represents increased tissue metamorphosis, it follows that there will be an augmentation in the production of carbon dioxid and a demand on the part of the system for more oxygen. This can be supplied only by more rapid respirations and an accelerated circulation. The necessity for the latter is still further increased by a diminution in the number of red blood-corpuscles, the oxygen-carriers of the blood. The production of an increased amount of heat also increases the number of respirations, together with the pulse-rate, this increase occurring independently of tissue changes. Irritation from want of oxygen likewise disturbs the centers of respiration and circulation. While either the want of oxygen or the increased heat may in some cases act as direct irritating causes, in other instances the direct action of the pyrogenic agent may be the stimulant to the nerve-centers. This is probable from the fact that other abnormal qualities of the pulse, such as dicrotism, may occur in fever. This phenomenon results from a relaxation of the wall of the vessel and a consequent decrease in arterial tension. Sphygmographic tracings in connection with animals which had inhaled nitrite of amyl, or had been injected with atropin, showed dicrotic tracings. It has also been claimed by some observers that almost every form of fever produces characteristic and peculiar changes in the pulse, those produced by traumatic fever differing from those produced by erysipelas, those produced by intermittent fever differing from those produced by remittent fever, all these in turn differing from one another and from the pulse observed in the exanthemata.

In simple traumatic fever pathologic changes in parenchymatous organs are scarcely ever observed. In the fever of wound diseases, however, they

do occur, and will be described in that connection. It is sufficient to mention here that these changes may depend on the presence of heat. But this fact will not of itself suffice to explain these phenomena. It has been observed that special and peculiar degenerations follow the administration of specific poisons, as phosphorus and arsenic. In the same manner the specific action of certain pathogenic bacteria may produce characteristic and peculiar lesions. This has been demonstrated by experiments made by Koch, C. Voit, and others. Animals whose secretions after several days of hunger remained unaffected, were subjected to artificial heat. The decomposition of albuminous elements was not thereby affected.

Resorptive or Aseptic Fever.—Traumatic or wound fever, as it is sometimes called, is caused, as has been shown, by a pyrogenic agent which has its origin in a wound whose secretions have undergone putrefaction and become putrid. This is to be distinguished from another form of fever produced by the passage of dead tissue into the blood, the further destruction and oxidation of which occurs without the bacteria of putrefaction. This is known as **aseptic fever,** or the **fever of resorption** (Volkmann). It is analogous to that which follows intravenous infusion of solution of sodium chlorid, transfusion of the blood of animals, and experimental fever resulting from intravenous injections of flour and water, etc. Like these, aseptic or resorptive fever is characterized by rapid onset and short duration, which distinguish it from wound fever proper. Volkmann pointed out the analogy existing between this fever and that which is observed to follow simple fractures, which results from resorption of effused blood in large quantities. The blood is overfilled with dead albuminous substances, originating from the extravasated blood, its broken-down corpuscles and other detritus, and an increased process of oxidation is rendered necessary to dispose of it.

The transformation of the albuminous substances which accumulate in the blood in aseptic fever is probably due to ferments already existing, and not introduced from without. Resorptive fevers and even death from extensive coagulation of blood in the vessels occurs after the injection into the veins of animals of Schmidt's **fibrin ferment,** a substance obtained from defibrinated blood itself. Some of the digestive ferments, such as pepsin and pancreatin, will likewise produce similar results. Whether the wound is accidental or operative, aseptic fever occurs when the blood escapes into the wound cavity, or when the particles of broken-down tissue, with the effused blood, undergo resorption. It is claimed for these resorbed products that they are but slightly altered from their normal condition, not having undergone putrefactive or other changes, and that the fever resulting from their presence should not be confounded with febrile conditions associated with well-known putrefactive changes and included under the general term of sepsis. The necrosis of tissue may be the result of the antiseptic agent employed as well as the result of the damage done to the tissues by the traumatism inflicted.

Resorptive or aseptic fever may follow the injury within a few hours, and is usually of short duration, rarely lasting beyond the third day. The temperature may rise from one to three degrees above the normal. This fever does not produce, as does septic fever, a profound impression on the sensorium, nor do the patients, as a rule, complain greatly of discomfort from its presence.

The appetite is not usually affected. These points, as well as the fact that it subsides at about the time when septic fever begins, distinguish it from the latter, into which, however, it may imperceptibly merge. It is questionable if the term "aseptic fever" is admissible as applied to this condition, for the reason that the changes described as occurring in the effused products of inflammation and the debris of the wounded surfaces, as compared with the changes of putrefaction, are differences of degree rather than of kind.

TREATMENT OF INFLAMMATION

The **preventive treatment** of suppurative inflammation consists in maintaining in an aseptic condition, as far as possible, the part injured or diseased. The curative treatment will include the employment of antiseptic measures. In the majority of accidentally inflicted wounds the germs of putrefaction gain admission to the effused blood and lymph, where, under the favorable influences of heat and moisture, and in the presence of a proper pabulum, they proliferate. Under these circumstances a thorough disinfection of the parts will be necessary in order to protect the patient from the effects of the noxious agents which have infected the wound. This process of disinfection constitutes the antiseptic treatment of wounds.

Failure to establish or to maintain a rigidly aseptic condition in operation wounds may permit them to become infected to as dangerous an extent as those accidentally inflicted, and may require antiseptic measures in the after-treatment. Under some circumstances it may be difficult or impossible to accomplish even a relative asepsis. Probably such a thing as absolute asepsis is not attainable. On account of the minute character and general dissemination of the germs of putrefaction it is beyond the possibilities of human skill and foresight to close effectually every channel to their entrance. But, fortunately, the serum of the blood is itself a germicide which will protect the tissues, and, unless too heavily invaded, will enable them to withstand the effects of lesser degrees of putrefaction and germ proliferation. Different tissues, as well as individuals as a whole, may possess varying powers of resistance, and the question of infection will depend on (1) a greater or lesser **dosage**; (2) the degree of local or general **vital resistance.**

Finally, in some individuals, the victims of accidentally inflicted wounds or the subjects of cutting operations, the organism already contains noxious agents which may be transported to the wound and give rise to disturbances more or less pronounced, independent of local sources of infection. This, however, is comparatively rare. As a rule, the more rigid the enforcement of aseptic precautionary measures in operation wounds, on the one hand, and the earlier and more persistent the application of antiseptic measures in wounds that have become septic on the other, the better the results.

Aseptic Operative Technic.—This consists in the employment of methods which will, as far as possible, sterilize the site of the wound and all articles which are likely to come in contact with it, together with the hands and person of the surgeon and his assistants. Experiments have shown that a large number of pathogenic bacteria have their habitat on the cutaneous surface of the body (Cheyne). Others, which are less virulent, but which may become actively pathogenic under conditions of lessened local vital resistance,

such as **Staphylococcus epidermidis albus** (Welch), are also present, in addition to others that are positively harmless. Only criminal carelessness will permit a surgeon to make an incision into integument which has not been deprived, as far as possible, of lurking sources of danger. No disinfection or sterilization of instruments, care in the operative technic, nor application of antiseptic dressings can compensate for failure in this respect.

The Preparation of the Patient.—This consists in giving a general bath about twelve hours before the operation, and scrubbing that portion of the surface of the body in the neighborhood of the proposed operation which is likely to be exposed in the operating field, with a bristle hand-brush and strongly alkaline soap (sapo viridis of the Pharmacopœia) and warm water. The parts are shaved, rinsed, and covered with a compress wetted with the borosalicylic solution of Thiersch (salicylic acid, 15 grains; boric acid, 90 grains; water, a pint), covered with oiled silk and bandaged carefully in place. The object of this application is the further separation of the dead epithelium; the power of salicylic acid in effecting this separation is well known. After the patient is anesthetized the compress is removed and the parts again washed with soap and water, a bunch of gauze being substituted for the brush. This second scrubbing is followed by rinsing with 95 per cent alcohol and then with ether, to remove the secretions of the glandular apparatus of the skin excited by the manipulation, which of themselves contain microorganisms. The skin is now freely moistened with a 1:2000 solution of sublimate in 50 per cent alcohol, which is allowed to dry on the surface. On parts already in an inflamed condition, and in connection with which it is difficult to employ the scrubbing process, solutions of carbolic acid, 2 to 3 per cent, because of their well-known power to penetrate through the epidermis into the cutis, may be applied, and the more vigorous cleansing measures postponed until the patient is anesthetized.

The **mouth, pharyngeal cavity, female genitals, rectum,** and **bladder** require special care in the preparation. The mouth and pharyngeal cavities are cleansed for a day or two before the operation by frequent rinsings and garglings with a 1 per cent solution of chlorate of potassium or a wine-colored solution of permanganate of potassium. The teeth are to be brushed vigorously with a stiff toothbrush and all tartar removed. Ulceration and suppurative conditions are to be allowed to heal, if possible. Carious teeth should be removed. The vagina should be douched for a day or two before the operation with a warm borosalicylic solution, or a 2 per cent carbolic acid solution, and tamponed with iodoform gauze. Immediately before the operation it should be cleansed with gauze and soapsuds, and afterward irrigated. If putrefying processes are present (*e. g.*, breaking down carcinoma of the cervix), the diseased tissues are to be curetted away and the surface cauterized with the thermocautery. In operations in and about the rectum the patient should be restricted to a fluid diet and the bowels kept free by salines, aided by enemas of glycerin and water, for a day or two beforehand. During the operation, after the lower bowel has been cleansed, the upper part of the rectum is tamponed with gauze. After the operation, unless some contraindications exist, bowel movements are to be prevented for several days or a week by the judicious use of opium. If cystitis is present, the bladder should be frequently irrigated with a 2 per cent solution of salicylic acid or the borosalicylic solution of Thiersch (see above).

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Provision against reinfection is made by covering the patient with a sterilized sheet that has an opening admitting access to the field of operation, and, in addition, a number of sterilized towels are pinned carefully over the sheet. Unless the head is the part to be operated on, a towel should be placed upon it, turban fashion, to confine the hair.

The Preparation of the Surgeon and His Assistants.—The outer street clothing of the surgeon and his assistants is removed, and a freshly laundered white linen suit substituted. After all other preparations are com-

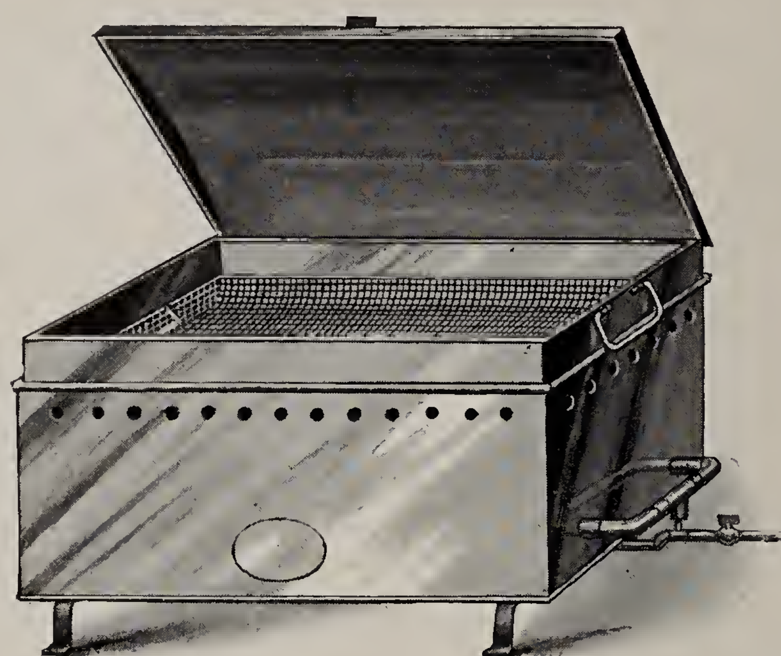

Fig. 5.—Schimmelbusch's Sterilizer for Boiling Instruments in Soda Solution.

pleted this is covered with a linen gown, steam-sterilized, the sleeves of which fit closely to the forearm and stop just below the elbow. The head is covered by a linen cap such as bakers wear, or an improvised turban made from a towel. No beard should be worn; at the most a mustache is permissible, and this is disinfected by a sublimate solution

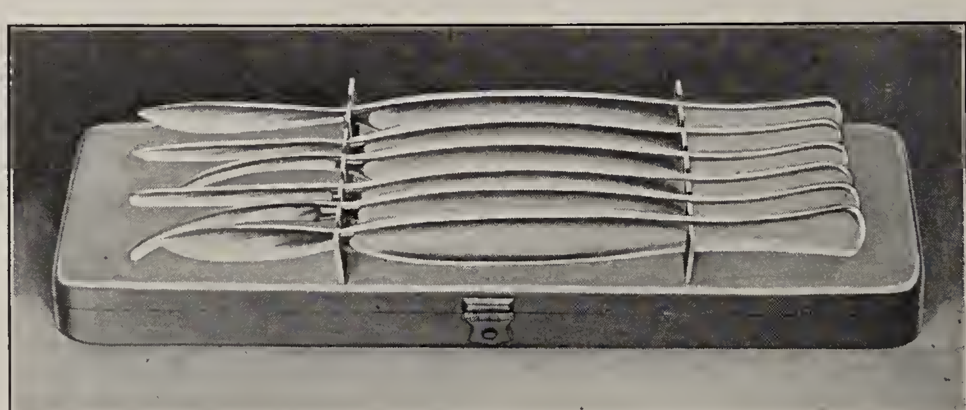

Fig. 6.—Scalpel Rack and Case.

before each operation. The nostrils and mouth should be covered with a mask of cheese-cloth to prevent the expulsion of infectious material in speaking, or accidentally coughing or sneezing. The hands, and particularly the subungual spaces, are the constant habitat of pyogenic organisms and require special care. The finger-nails should be kept closely trimmed. The hands must be scrubbed with a hand-brush and soap and running water for at least three minutes, particular attention being paid to the finger-tips; the nail

spaces are finally rubbed with gauze moistened with a 1:2000 solution of sublimate in 50 per cent alcohol and rinsed in a 1:2000 watery sublimate solution. They are then immersed in a 1:2000 solution of sublimate to which has been added potassium permanganate to saturation, until they are deeply stained. The hands should not be scrubbed too vigorously, since the irritation thus produced will lead to prompt reinfection of the surface from the passage of microorganisms from the depths of the skin. This will be still further enhanced by slight abrasions. If the hands remain stained with the permanganate sublimate solution, the surface is in a measure protected from reinfection from bacteria residing in the skin itself. After the operation is completed the stain is removed by immersing in a saturated solution of oxalic acid. If the sapo viridis

Fig. 7.—Arnold Steam Sterilizer.

Fig. 8.—Hospital Steam-pressure Sterilizer, Instrument Boiler, and Water Sterilizer.

of the German Pharmacopœia is used, both before and after the operation, the hands will not suffer from eczematous eruptions. Or, the hands may be stained in a saturated solution of permanganate after they are scrubbed, and this removed at once by the oxalic acid solution (Kelly). The oxalic acid itself is a potent factor in the sterilization. When the hands have been recently exposed to pus organisms, this course should be followed, and the hands restained in the permanganate sublimate solution above mentioned. Another

method is to wash the hands with ether and alcohol after scrubbing, and to immerse them for five minutes in sublimate solution (Fürbringer). Experiments have shown simple soap and water cleansing to be inefficient (Bole). The aseptic condition of the hands must be maintained during the operation by occasionally rinsing them, first in a watery sublimate solution, and then in alcohol. They are dried on a sterilized towel before being brought in contact with the wound.

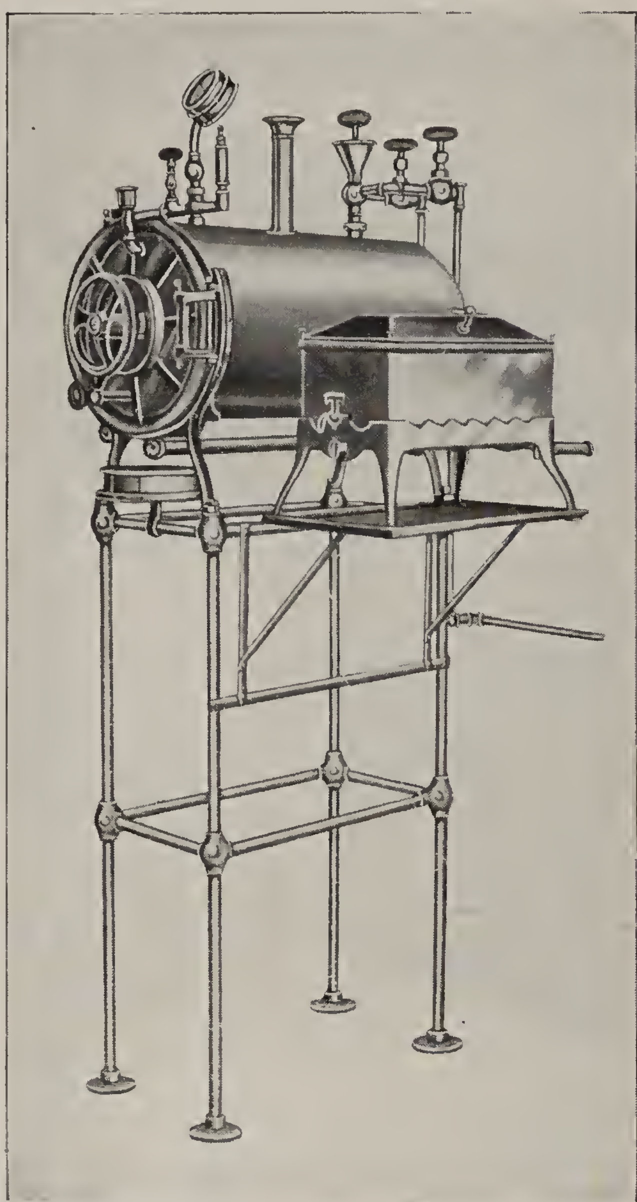

Fig. 9.—Small Steam-pressure Sterilizer and Instrument Boiler.

Disinfection of Instruments.—The simplest and at the same time the most trustworthy plan is to boil the instruments for five minutes in a 1 per cent solution of the alkaline carbonate of soda (sal. soda of commerce). They are afterward placed in trays which have been boiled in the soda solution and filled with a cold boiled soda and carbolic acid solution, 1 per cent, Schimmelbusch (Fig. 5). In the absence of suitable trays the instruments may be placed on sterilized towels and covered with them. The latter method is preferred by many operators. During the operation the instruments are rinsed, when soiled, in boiled water, or a 2 per cent carbolic solution. After use they are rinsed in the same solution, then in hot water, again boiled in the soda solution, scrubbed with soap and water, rinsed in hot water, and carefully dried. In order to withstand the damaging effects of this treatment the instruments should be made of metal throughout. After the other

Fig. 10.—Wringer for Hot Towels, Gauze, Etc.

instruments have been boiled the edged instruments should be placed in the boiler in racks (Fig. 6) to prevent their edges from becoming dulled by coming in contact with one another, and boiled for two minutes.

The Disinfection of Gowns, Sheets, Towels, Gauze, and Dressing Materials.—This is best accomplished by exposure to flowing steam, or steam under ten pounds pressure and upward, for forty-five minutes. A convenient apparatus for the former is the Arnold steam sterilizer (Fig. 7). In order to prevent the materials from becoming wet in the sterilizer by condensation of the steam thereon, they should be first warmed. For sterilizing on a large scale for hospital purposes the steam-pressure apparatus (Fig. 8) is to be used. A convenient combination of steam-pressure sterilizer and instrument boiler for office use is shown in Fig. 9. For boiling instruments in soda solution and sterilizing gowns and dressing materials by steam at the same time the

Fig. 11.—Apparatus for Sterilizing Catgut by Boiling in Alcohol.

A, fruit jar containing jelly jars filled with catgut; B, Dowd's condenser; C, water-bath; D, rubber cork connecting the jar with the condenser; E, tube extending from body of condenser through which the condensed vapor of the alcohol flows back into the jar; F, tubing connected with cold-water faucet; G, outflow tube for water from the condenser; H, cotton-sealed receptacle for overflow of alcohol; I, gas stove.

sterilizer of Schimmelbusch is convenient and efficient. Squares of gauze to be used in place of flat sponges in abdominal section, which require to be warm when brought in contact with the intestines, may be boiled in a 0.6 per cent solution of common salt (Tavel) and kept therein until ready for use, when they are wrung out (Fig. 10).

The Sterilization of Ligature and Suture Material.—This is of the first importance. In spite of the unfortunate experiences of Volkmann, who observed cases of anthrax arising from infection of wounds by catgut, surgeons are loath to abandon catgut as a ligature material. It may be boiled in 95 per cent alcohol for an hour without impairing its strength, as I have

heretofore shown,* and laboratory experiments made for me by Dr. Hodenpyl prove that gut thus prepared is sterile even after previous infection with anthrax. Since the temperature reached by boiling alcohol (185° F.) can scarcely be deemed sufficient to effect sterilization alone, particu-

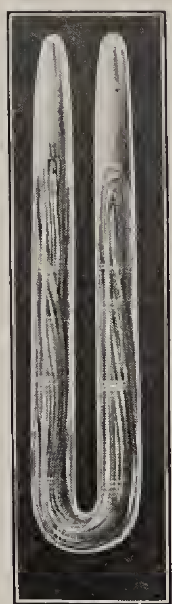

Fig. 12.—Hermetically Sealed Bent Glass Tube Containing Sterilized Catgut.

Fig. 13.—Breaking the Tube.

larly when the catgut has been previously infected by anthrax, it must be assumed that in the method of boiling in alcohol the efficiency of the sterilization must depend to a great extent on chemic processes occurring in connection with the heated alcohol. The use of catgut in my hands has been followed by the most satisfactory results in cases in which it has been buried in the tissues. It should never be used as a skin suture for the reason that it is almost impossible to disinfect the skin in its depths, and the catgut, though sterile, passing through this structure serves as a pabulum in the presence of which bacteria already present rapidly proliferate and produce irritation, and at times infection. An apparatus for sterilizing catgut by boiling in alcohol, which has the double advantage of safety and economy of alcohol, as originally suggested by me, has been devised by Dr. Dowd (Fig. 11). Catgut may be placed in bent glass tubes, which are filled with alcohol, hermetically sealed and exposed in an oven to a temperature of 185° F. (the boiling-point of alcohol) for an hour (Fig. 12). When required for use, the tube is simply broken (Fig. 13). Fractional sterilization of catgut by means of dry heat in a hot-air sterilizer (Fig. 8) has been proposed. Slowly heating it to 140° C. and exposing it to this temperature for three hours is said to be efficient (Reverdin, Boeckmann). Another method consists in first immersing the gut in ether for

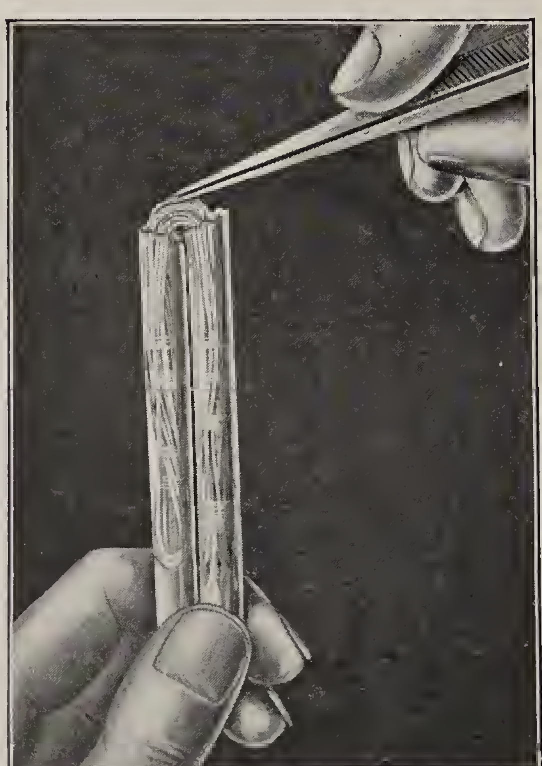

Fig. 14.—Removing the Catgut.

* New York Medical Journal, Aug. 16, 1890.

two days (B r a t z) to remove the fat, and then in a 1:500 solution of sublimate in alcohol for six hours, and thence transferring it to pure alcohol; or, after washing in ether for three or four consecutive days it may be permanently kept in a 1 : 500 ethereal solution of sublimate (S c h a p p s). Alcohol 1000 parts, glycerin 100 parts, and sublimate 1 part, has been recommended as a preservative medium (B r u n n e r). If stiff gut is desired, the glycerin is to be omitted (B e r g m a n n). The **iodin method** consists in permanent immersion in a 0.33 per cent solution of iodin in alcohol. It is immersed one week before using. Sterilization by means of **combined heat and cumol** (Johns Hopkins Hospital) requires a special apparatus, as well as some handling during the process. Kangaroo tendon and all other animal ligature material must be sterilized in the same manner as catgut. **Silk, silkworm-gut,** and like suture material may be conveniently sterilized by placing them in the steam chamber with the dressing materials, or preferably by boiling them for five minutes in a 0.6 per cent salt solution for each operation (T a v e l).

Dressing of the Wound.—Except for the purpose of washing away blood-clot, irrigation of the wound will not be required in aseptic operations. The wound should be kept as dry as possible (L a n d e r e r). When necessary, a solution of salt in sterilized water, one dram to the pint, is to be used. The necessity for drainage in an aseptic wound is exceptional. It may be required, however, where there are large dead spaces which cannot be obliterated by deep sutures or by the pressure of the dressings, or where extensive dissection has been made. Generally speaking, with entire arrest of hemorrhage and careful removal of all blood-clot an aseptic wound may be closed completely. The dressing of an aseptic wound consists in covering it with simple sterile gauze in sufficient quantities to protect it properly, applying a thick layer of steam-sterilized nonabsorbent cotton, and securing the whole in place by a method of bandaging adapted to the part operated on. As rapid evaporation of wound secretions plays an important part in preventing putrefactive changes in aseptic wounds, impermeable coverings are not only unnecessary but mischievous. Where means for steam sterilization are not at hand, the gauze may be boiled in the 0.6 per cent salt solution and wrung out as dry as possible before being applied, large quantities being employed, and the cotton omitted.

When it is necessary to perform the operation in a private dwelling-house, additional precautions are to be taken, in order to prevent infection from the patient's surroundings. These consist in clearing all furniture from the room, removing all hangings, window curtains, etc., and thoroughly wetting the carpet several times in advance with a 1: 1000 sublimate solution. Woodwork and walls are to be washed and disinfected with the same solution. Permanent fixtures are to be covered with sheets wrung out of sublimate solution. Doors opening into closets are to be closed and sealed by plugging the cracks and keyholes with cotton.

A reasonably trustworthy aseptic immediate environment may be improvised in private dwelling-houses, and this in the main with the means ordinarily at hand, with the addition of a supply of sublimate tablets. Freshly laundered sheets may be used to cover a well-scrubbed domestic table to be used as an operating table, fixed articles of furniture or those too heavy to be

removed from the room, and the patient after the anesthetization and final preparation. The immediate field of operation may be surrounded by towels first boiled in saline solution and then wrung out of a sublimate solution. Washing soda from the household supply will serve to make the solution for boiling the instruments, and soap from the laundry will answer for cleansing the patient's skin and the hands of the operator and his assistants. Gauze for sponging and wound-dressing purposes may be sterilized by boiling for ten minutes in Tavel's solution made with sufficient accuracy by dissolving a teaspoonful of table salt in a pint of water. Clean sheets arranged in Roman toga fashion may be substituted for operating gowns. Utensils selected from the kitchen outfit for boiling the instruments and gauze, a fire in the kitchen stove, and a plentiful supply of boiled water will serve for the rest.

The Antiseptic Treatment of Wounds.—Every wound that has been exposed to infection must be treated antiseptically. Wounds already infected must be protected against infection by an antiseptic regimen. In accidentally inflicted wounds the parts must be cleansed, foreign bodies removed, and bruised tissue likely to die cut away. The surroundings are to be shaved, scrubbed, and disinfected precisely as if no infection had taken place. The wound itself is to be irrigated with a 1:2000 sublimate solution and closed, drainage being provided for. An alcohol sublimate solution consisting of mercuric chlorid, 1 part, and 50 per cent alcohol, 2000 parts, may be used with advantage at the first two or three dressings in suppurating wounds, the cavity of the wound being packed with gauze wrung out of this solution.

Drainage.—This may be provided for (1) by leaving the entire wound, or at least the most dependent part thereof, open; (2) by enlarging wounds too small to permit of drainage (compound fractures); (3) by making counter-openings at proper points; (4) by securing primary drainage and secondary suture, *i. e.*, placing sutures in position, leaving the wound open, and packing it with iodoform or other antiseptic gauze, and in the course of twenty-four or forty-eight hours drawing its edges together with the sutures already placed (Kocher); (5) by using drains, either capillary or tube. Capillary drains, consisting of wicking, plain or wrapped in gauze, perforated oiled silk, or rubber tissue, or narrow strips of gauze, will conduct away serum if the wound is a recent one. Narrow strips of oiled silk or rubber tissue will also be of service, under the same circumstances. For tube drainage fenestrated rubber or annealed glass is generally used. When extra rigidity of the walls of a rubber drainage-tube is required, the latter may be immersed for five minutes or more, according to the size, in commercial sulfuric acid (Javarro). In order to avoid the necessity for the removal of tube drains it has been proposed to employ those made of bone and subsequently decalcified (Neuber) or those of the long hollow bones of fowls (Macewen, Trendelenburg). Tube drains should be prevented from slipping too far into the wound by a safety-pin placed across them at their point of exit. Whatever material is employed for facilitating drainage from a wound should be removed and dispensed with as soon as possible. Its presence exerts an irritating influence and excites secretion from the wound surfaces. All drains before being introduced into the wound should be sterilized by boiling.

Antiseptic Dressing.—The antiseptic dressing of a wound demands that absorbent material impregnated with an antiseptic agent, and hence capable

of disinfecting septic discharges, be applied. Sterilized gauze wrung out of sublimate solution will answer in many cases. Iodoform gauze treated in the same manner is very useful. Where dermatitis results from contact of sublimate or iodoform, and where the toxic properties of the latter are to be feared, gauze wrung out of a mixture of oxid of zinc in sterilized water is to be substituted. In chronic suppurating cases (ischiorectal abscesses, etc.) iodoform gauze wrung out of alcohol is very efficient. Disarrangement of the dressings by the restlessness of the patient should be provided against by the application of proper splints, adhesive plaster, starched crinoline, or plaster-of-Paris bandages, in addition to the ordinary bandages. These serve also as important additional means of securing prompt healing in parts otherwise freely movable, by insuring rest. Moderate compression to overcome muscular spasm is useful in all dressings, and the influence of position in securing comfort and facilitating drainage is to be borne in mind.

The indications for redressing a wound, exclusive of those which arise from accidental displacement or soiling from without, are as follows: (1) the occurrence of pain due to tension from swelling or accumulation of wound secretions; (2) the appearance of discharge on the surface or at the edges of the dressings; (3) the necessity for removal of the drain; (4) the removal of the sutures; (5) the rise of temperature after the first twenty-four hours, showing the occurrence of systemic infection from the wound as a septic focus. In order to recognize promptly the last-named indication the temperature should be taken every four hours during the first few days. On removing the dressings the condition of the wound and surrounding parts must be carefully investigated. Tension on sutures is to be relieved by removal of one or more of these. Pent-up discharges are to be furnished exit by separating the wound edges. Slough or clots are to be removed by the curet. Inflamed or phlegmonous conditions in the neighborhood are to be relieved by reopening the wound, and by incisions in addition, and they, as well as the original wound, are to be treated by sublimate irrigation and tamponed with iodoform gauze wrung out of alcohol or wet sublimate gauze. Compresses of the latter are to be applied as dressings, and daily or twice daily reapplications of these practised until the symptoms disappear. When a simple serous or serosanguinolent discharge appears and no other symptoms are present indicating removal of the dressings, this, if it dries rapidly, may be covered by another sterile or antiseptic dressing. The drainage-tube may be removed on the third day, unless some positive indication for its further use exists. If there is any doubt as to this, it may be shortened at each dressing.

The occurrence of **stitch abscesses** in skin which has been cleansed with the most scrupulous care is to be attributed to the presence of Staphylococcus epidermidis albus of Welch. This observer found that after sterilization of the surface the presence of this coccus could still be demonstrated by making cultures from sutures passed through the skin, or from excised portions of the skin. While ordinarily innocuous, under the influence of lessened local vital resistance, such, for instance, as the strangulation of tissues and the resulting necrosis from the pressure of a stitch-loop, or the presence of foreign bodies in the wound, it may become the cause of disturbance manifested by localized suppuration and elevation of temperature. No time should be lost in relieving the pressure; the sutures should be removed and the infected tissues

through which they pass curetted to remove all necrotic tissue, with a sinus curet (Fig. 15). Each suture track should then be disinfected and packed with antiseptic gauze.

The time for the removal of the sutures will depend on the exigencies of the case. They should not be permitted to bury themselves in the skin, except under exceptional conditions. Where no tendency of the wound edges to gape is present, they may be removed early. On the contrary, wounds involving the abdominal wall will require a longer support.

Under circumstances in which it has been necessary to remove sutures on account of septic conditions, as well as when it has been necessary to omit these from the commencement, with the subsidence of the local inflammation and in the presence of healthy granulations, attempts to close the wound and hasten the healing process may be made by the use of either adhesive plaster strapping or **secondary sutures.** Care should be taken to prevent rolling in of the skin edges.

Fig. 15. Delatour's Sinus Curet.

Finally, in summing up the indications for redressing a wound emphasis is to be placed on the dictum that, in doubtful cases, it is better to dress the wound once too often than once too seldom, and then perhaps too late. On the other hand, the general principles of quiet and infrequent dressings are to be borne in mind. While a careful watch should be kept for indications for removing the dressings, meddlesome and unnecessary interference does harm. The act of dressing should be carefully performed and all precautions taken to prevent further infection. Too much sponging and wiping and even forcible irrigation is mischievous. Whatever causes bleeding from the wound is to be avoided.

Losses of substance or severely contused conditions of the wound may lead to **failure to approximate the wound edges.** It should be tightly packed after being cleansed, if sepsis is suspected, or covered with simple sterile dressing if not. If an antiseptic condition is maintained, granulations gradually fill up the space. The discharge consists of plasma and a few migrating cells or leukocytes. The completion of the healing process is marked by the formation of a skin covering from the rete Malpighii at the margins.

The occurrence of **profuse granulations** is to be met, if these are florid and due to the too rapid development of vessels, by the application of caustic substances, such as the nitrate of silver, or by removal by knife or scissors. If pale and flabby from an edematous condition, and particularly if a tuberculous infection is present, they must be curetted away, and stimulating and antituberculous remedies, such as combinations of naphthalin and iodoform, or Peruvian balsam, applied.

In foul-smelling wounds with grayish, sloughy-looking surfaces the curet should be vigorously used, followed by the application of a 10 per cent solution of chlorid of zinc. This should be well rubbed in and followed by packing with a stimulating antiseptic gauze (gauze treated with naphthalin and Peruvian balsam). The process of curetting and "scouring" should be repeated, if necessary, at subsequent dressings.

One of the sequels of an infected wound is an opening or **sinus** leading from the surface to a suppurating cavity.

The infected area is to be thoroughly curetted with the sinus curet (Fig. 15) and treated by stimulating and bactericidal agents, injected into its depths and incorporated in gauze and carried to the bottom of the sinus. Chlorid of zinc, followed by hydrogen peroxid, the latter principally for its mechanical cleansing properties, and, after irrigation, the introduction of Peruvian balsam incorporated in gauze fulfil the indications, as a rule. A persistently discharging sinus may be due either to the presence of necrosed bone or other foreign body or to septic conditions involving the walls. The former should be searched for and removed; the latter should be met first by thorough curetting followed by injection of the sinus with a 95 per cent solution of carbolic acid by means of a sinus syringe (Fig. 16). After the lapse of from one to two minutes the carbolic acid is dissolved and washed away with alcohol and the opening dressed with sterile gauze without drainage. Or, equal parts of carbolic acid and tincture of iodin may be injected and the parts dressed at once with sterile gauze.

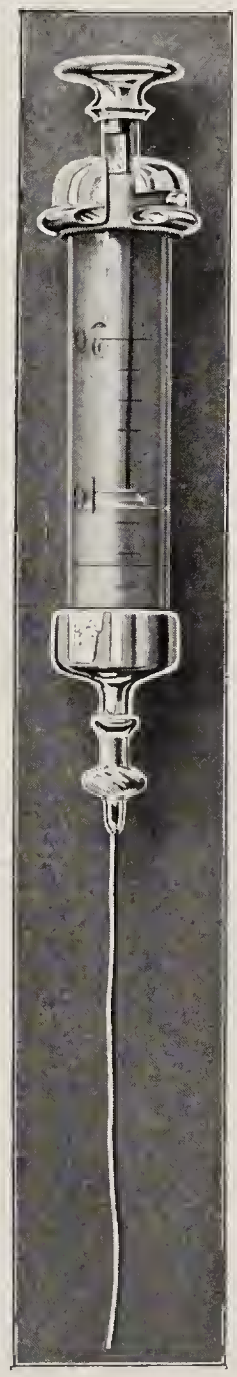

Fig. 16.—Sinus Syringe.

Antiseptic Agents.—Antibacterial or antiseptic agents are those drugs and appliances which either possess a destructive (disinfectant, sterilizing) power or exert an inhibitory influence in their relation to microorganisms. Of the first of these, the most powerful is heat. This is applicable only to instruments, dressing materials, etc.

Corrosive Sublimate (Mercuric Chlorid).—This bactericidal agent is most generally applicable to the requirements of antisepsis in its relation to the body. The demonstration of its bactericidal properties (Koch) was soon followed by its introduction into surgical practice (Schede; Bergmann, 1878), and it almost completely replaced carbolic acid, which under the influence of Lister's teaching was theretofore the most universally employed antiseptic. It is usually employed in solutions of from 1:1000 to 1:5000, though the weakest of these is irritating to the tissues in some situations (the eye and urethra). In joint cavities a 1:5000 solution is employed. The vaginal canal may be irrigated with a 1:3000 solution, and the uterine cavity as well, if proper provision for the return flow is made beforehand by thorough dilatation of the cervix. A solution not stronger than 1:20,000 is to be employed in the urethra in the beginning; as the sensitiveness lessens under frequent use and instrumentation, the strength may be increased. A sublimate solution is never to be employed in the mouth or rectum for irrigating purposes on account of its toxic properties; abdominal pain, tenesmus with bloody mucous stools, etc., follow. These symptoms may also occasionally follow absorption from wound surfaces, though they are rarely of so pronounced a character. Such disagreeable symptoms as eczema, salivation, and stomatitis may occur in sensitive individuals. These, as well as the slight superficial necrosis which follows contact of the tissues with the stronger

solutions, may be prevented to a considerable extent by washing the latter away subsequently with the sterilized normal salt solution. The presence of alkaline earths in common water interferes somewhat with the solubility of corrosive sublimate, and for this reason the addition of some acid, such as tartaric, citric, or acetic acid, is useful. Ammonium chlorid (sal ammoniac) or sodium chlorid (common cooking salt) will act as correctives in effecting the solution. In the case of any of these agents the amount employed should equal that of the mercuric chlorid. The beneficial results following the use of mercuric chlorid as a local application to infected wounds are greatly enhanced by the addition of alcohol to the solution (corrosive sublimate, 1 part, alcohol and water, of each 1000 parts). Experimental research confirms the results of clinical experience as to the value of mercuric chlorid and the other bactericidal agents in antiseptic wound treatment (Henle). Its availability, cheapness, and undoubted disinfectant properties have combined to render it the most popular agent of its class.

Mercuric Iodid.—This is a trustworthy antiseptic of the bactericidal closs, and is used more especially in operations on the eye. Its effects on polished instruments are not so pronounced as those of corrosive sublimate. It is used in strengths varying from 1:4000 to 1:12,000. Its solubility in water should be aided by the addition of an equal portion of potassium iodid. The expense of its manufacture as compared with the expense of mercuric chlorid has been a bar to its universal employment.

Carbolic Acid.—This is one of the inhibitory antiseptic agents, and is employed in the strength of from 2.5 to 5 per cent. It possesses the property of decidedly penetrating the skin surface (Hueter), and for this reason, in connection with opium and sufficient glycerin to assure the solubility of the carbolic acid, is a useful application in inflammatory conditions of the surface, replacing the lead and opium wash of the older surgeons. To each pint of a 2.5 per cent solution one ounce of tincture of opium is added. It should be used with caution in young children and old persons. Its **toxic properties** are first manifested in connection with the kidneys, the urine becoming a dark olive-green or black. Nausea, vomiting, and a rapid and small pulse are the other symptoms, followed by coma and death. Carbolic acid may be found in the urine. It should not be used in cases in which chronic degenerative diseases of the kidneys exist. It is absorbed through both the lymph-channels and the blood-vessels; in the case of the skin it passes through the thin epidermis and into the vessels, hence its value in septic dermatitis and cellulitis. This also explains the fact that young children with very delicate epithelial covering, and old persons with atrophic skin are specially susceptible to its influence when it is used in this manner. The **treatment of carbolic acid poisoning** consists in suspending the use of the drug, stimulating with alcohol and camphor, the administration of 10- to 20-gram doses of sulfate of soda (Sonnenburg) if the urine remains dark colored, and the application of dry cups in the renal region and intravenous saline infusion if suppression is threatened. Local troublesome eczema may follow its prolonged use as a wound dressing.

Zinc Chlorid.—This is a very useful antiseptic, and was employed as early as 1866 (Campbell de Morgan) after operations for carcinoma. Later it was employed in the primary treatment of compound frac-

ture (Lister, Volkmann), and as a permanent wound dressing (zinc chlorid lint and jute, Bardeleben). It may be used in extremely septic wounds of long standing in a 10 per cent solution. In those in which less energetic measures are required, a 5 per cent solution will suffice. As a permanent dressing it is irritating to the skin.

Salicylic Acid.—This is one of the synthetically produced antiseptics. It is used in strengths of from 1:300 to 1:100; its solution in water is aided by the addition of six times its weight of boric acid (Thiersch: salicylic acid 15, boric acid 90, water 500). It is nonpoisonous in these strengths, and is employed for irrigating purposes where sublimate solutions are unsafe. It is a useful application to the skin in preparing the latter for operation, because of the property which it possesses of separating dead epithelial scales from the surface.

Iodoform.—The antiseptic properties of this agent are developed by the liberation of free iodin in the presence of the products of bacterial decomposition (ptomains and toxalbumins). When employed in cases in which suppuration is not present it should be sterilized before being used. It is said to possess hemostatic properties. It is used principally in tuberculous disease, and as a mild inhibitory agent to the growth of pyogenic organisms. A 10 per cent emulsion of iodoform in glycerin is used as an intraarticular and parenchymatous injection in tuberculous affections of bones and joints. It is slow in its action, owing to its insolubility. Its principal use is in the shape of iodoform gauze for tamponing cavities in the neighborhood of the rectum and vagina, particularly when free oozing of blood occurs from these, and as an antituberculous application to the wound surfaces after resection and erasion of tuberculous joints. Iodoform gauze is sometimes used to wall off septic intraperitoneal areas from the remainder of the cavity of the abdomen, as in suppurative appendicitis. The **toxic properties** of iodoform are pronounced and the **symptoms of poisoning** are of both a general and a local character. The former are the more important, and consist of headache, nausea, and vomiting; in more serious cases increased frequency of the pulse, rise of temperature, confusion of ideas, delirium, coma, and death follow. The symptoms and postmortem appearance resemble those of acute meningitis. Old persons and young children are peculiarly susceptible to its toxic influences. Withdrawal of the drug will usually arrest the early symptoms. The same general measures of treatment as in carbolic acid poisoning are used. The use of sodium chlorid in large quantities has been suggested as an antidote. Intravenous saline infusion should be employed.

Acetate of aluminum, a nonpoisonous agent, is used as an astringent and mild antiseptic solution in certain phlegmonous affections requiring permanent immersion and irrigation. It is used in from 1 to 3 per cent solutions (Bürow). The following formula affords a ready means of making a 1 per cent Bürow's solution:

Alumen	5 parts
Plumbi acetas	25 parts
Aqua	500 parts

Creolin is used in the shape of a milky mixture with water in the proportion of from one to two parts in a hundred, as a substitute for carbolic acid.

It is said to be nonpoisonous. **Lysol** belongs to the same class of coal-tar products as the last named, and is used in a similar manner. **Thymol** is very insoluble, and does not find a wide range of usefulness. In the proportion of 1:1000 it is an agreeable addition to certain mouth-washes. It is nontoxic.

Boric acid is the most frequently employed of the weak antiseptics. It is used principally for irrigating the bladder, cavity of the mouth, and rectum, and as an addition to solutions of salicylic acid (Thiersch's solution). It is also extensively employed in the shape of boric acid ointment.

In addition to the above, quite a large number of more or less useful antiseptic agents have been introduced, which may prove useful under special circumstances. Among these may be mentioned **naphthalin, subnitrate of bismuth, oxid of zinc, hydronaphthol, aristol, dermatol,** and **subiodid of bismuth.** Besides these, there are some which are supposed to exert a specific effect on the bacillus of tuberculosis, such as **Peruvian balsam** and **cinnamic acid.**

The Selection of an Antiseptic.—No hard and fast rule can be laid down for the selection of an antiseptic for any particular case. It is far more important that the surgeon should be familiar with the uses of a few antiseptics than that he should attempt to limit with sharply defined lines the special uses of a large number. For the purpose of aseptic irrigation ordinary sterilized saline solution (0.6 per cent solution of sodium chlorid) is all that is needed. Solutions in varying strengths of **sublimate, carbolic acid, zinc chlorid, salicylic acid,** or **boric acid** are used in suppurating wounds and cavities. **Iodoform** is most advantageously employed in tuberculous cases, and **Peruvian balsam** and **naphthalin** in indolent granulating surfaces and sinuses. As for the rest, they are more or less useful when incorporated in hygroscopic cheese-cloth or gauze. **Oxid of zinc** and **boric acid,** alone or combined, are useful dusting-powders.

Antiseptic Ointments.—These are but very little used at the present day, except where sensitive areas about a wound are to be protected against irritating wound discharges or contact with antiseptic substances. Vaselin one part and paraffin two parts form the best base for an ointment. **Salicylic ointment** is made by adding one part of salicylic acid to twenty-nine parts of the above base. **Boric acid ointment** is made by adding one part of the acid to ten parts of the same base. **Salicylic cream** is made by mixing one part of the acid to ten parts of glycerin. **Carbolized oil** in varying strengths (1:5; 1:10; 1:20) is likewise employed for the purpose mentioned, as well as for oiling the examining finger and instruments.

Dressing Materials.—Cheese-cloth, butter-cloth, or absorbent gauze, introduced by Lister, is the standard dressing material. Any of the antiseptic substances may be incorporated in this. Except in cases of special susceptibility, the most generally useful antiseptic dressing material is gauze wrung out of a corrosive sublimate solution. In strictly aseptic operations **steam-sterilized plain gauze** suffices. The antiseptic gauzes furnished by the manufacturers should undergo a further process of sterilization in the steam sterilizer before being used. The sterilization of the manufacturer is not to be trusted; sufficient time usually elapses between the sterilization and the final use to permit reinfection. When practicable, heat should be used for the sterilization.

Iodoform gauze cannot be sterilized by heat owing to the decomposition of the iodoform. It should be wrung out of sublimate solution before being used. **Peruvian balsam gauze** is a useful means of conveying this medicament into sinuses, etc. Should a still greater stimulating effect be desired, naphthalin may be added to the balsam in the proportion of one dram to the ounce. The gauze is simply saturated with the balsam and the superfluous portion pressed out. It should be heat-sterilized before being used. In addition to gauze dressing materials, which are relatively expensive, cheaper dressings have been devised to serve in making up the bulk of large dressings. These consist of **absorbent cotton** (Bruns); **jute** (Mosengeil); **peat moss** (Leisrink); **peat** (Neuber); **forest moss** (Hagedorn); **sawdust** (Pilcher); **wood-wool** and **paper-wool** (Fowler). These are made into cushions, and may be impregnated with antiseptic substances, but should be heat-sterilized before being used. **Cotton batting** furnishes a cheap and useful means for protecting dressings after they have been placed in position. In addition, it assists in the even distribution of pressure as applied by retentive bandages. It should be nonabsorbent for the reason that in this condition it is a more effectual barrier against microbic invasion, and it is to be heat-sterilized.

The method of applying gauze dressings is as follows: A yard square of the material is applied in a crumpled mass to the wound. This is repeated until several layers are placed in position, or the cushions of paper-wool may follow. Over the entire mass, particularly at the edges, is superimposed a thick layer of sterilized cotton wadding. The whole is secured in place with turns of a roller bandage, the latter preferably of gauze also.

Superficial wounds of the face may be treated without any dressing other than the application of collodion mixed with iodoform, subnitrate of bismuth, oxid of zinc, or boric acid or salicylic acid. Any of these latter may be applied as a powder dressing to superficial granulating surfaces or excoriations.

Local Antiphlogistic Measures.—There are certain local measures which, while in one sense acting to arrest septic symptoms, yet cannot be said to be directed against the cause of the inflammation in the sense of antisepsis. These **symptomatic remedies** are directed toward the arrest of spreading dermatitis and lymphangitis occurring in the neighborhood of infected wounds, which are not arrested by the remedies used in the wound itself or its immediate neighborhood. These consist of certain ointments and moist applications. **Zinc oxid ointment** is most commonly employed. The ordinary mercurial ointment is sometimes used for this purpose. A 10 per cent mixture of **ichthyol** with lanolin is another useful remedy.

The **local use of ice** is founded on rational therapeutic principles. It abstracts heat and locally diminishes the quantity of blood by contracting the vessels. It tends also to arrest the development of bacteria and lessens the pain, or abates it entirely. Its use, however, is restricted to cases in which large dressings are not employed, as, for instance, inflamed joints. Here also its use is limited. In joints in which the capsule is superficial, such as the knee-joint, it is of great advantage, while in the hip-joint it is entirely useless. The **local abstraction of blood** in inflamed areas, formerly so much in vogue, is now substituted by position, particularly in the case of the extremities; elevation of the inflamed parts answers all the requirements of local blood-letting.

So-called **derivatives** or **measures of counter-irritation** are used less frequently than in former times. **Blistering and cauterization** are still believed by many surgeons to be of service in chronically inflamed joints, particularly the knee-joint, when combined with fixation.

Tenosynovitis and chronic inflammatory conditions elsewhere are advantageously treated by **massage.** This consists of **massage à friction** (simple friction movements with the finger-tips), **effleurage** (rubbing with an ointment), **pétrissage** (kneading with both hands at right angles with the long axis of the parts), and **tapotement** (beating the soft parts with the ulnar margin of the hands or the closed fist). Massage is particularly useful in old cases of serous or serofibrinous inflammation and in cases of edematous swelling and infiltration following such injuries as severe sprains, fractures, and dislocations, and after the subsidence of suppurative inflammation. It is contraindicated in acute inflammation, particularly where this disposes toward suppuration. It should not be employed in specific or granular inflammatory conditions, lest further disseminations and propagation of pathologic elements be favored by forcing these into neighboring lymph-channels. Steadily maintained **equable pressure** favors lymphatic resorption. The roller bandage is a most useful antiphlogistic measure. The elastic bandage of Martin or the material known as **"stockinet"** is a valuable means of accomplishing this pressure. Care is necessary in the application. The ease with which a very slight pressure will serve the purpose is quite surprising. Only just enough pressure to hold the bandage in place is usually sufficient when the rubber bandage is employed. Elastic compression is employed with advantage as an adjunct method of treatment to massage. **Warm baths** are likewise useful in the treatment of old inflammatory residua. These may be simply of water of normal temperature, or certain medicaments and salts may be added to aid resorption. Some of the natural mineral springs, both thermal and salt, have a more or less well-founded reputation in the treatment of this class of cases.

Finally, certain **local antibacterial** measures have, in recent years, been introduced for the specific local treatment of granulating inflammations. These will be considered under the head of the special diseases in which they are employed.

The Constitutional Treatment of Inflammation.—While the local treatment of inflammation demands our first and greatest care because of the now well-recognized causes of the processes which contribute largely if not exclusively toward bringing about the condition, yet the constitutional state should not be neglected. The local application of cold, while restricted in its use, serves at the same time as a general refrigerant measure. The application should be made as near the inflamed part as possible. Running water used at room-temperature, or cooled by the addition of ice, is the most useful. A convenient arrangement for the purpose is the **ice-coil** (Fig. 17).

The administration of **antipyretic drugs** is to be discouraged, as far as possible, in the treatment of surgical inflammatory fever. The use of quinin, formerly so extensively employed, is now limited to tonic doses. The synthetically prepared coal-tar products used in general medicine are all more or less harmful in surgical practice, first, because they mask the real condition, and, second, because of their depressing influence. The specific or granulating

forms of inflammation are not, as a rule, accompanied by very marked febrile disturbances, except possibly for a brief period at the commencement of the infective process. This is particularly true of **syphilis.** General mercurial treatment is indicated as soon as the diagnosis is established. No specific has been discovered for tuberculosis and leprosy analogous to that which we possess for syphilis. In the absence of this, every effort must be made to build up the tissues in a manner calculated to render the cellular elements resistant to the inroads of the specific bacillus on which the granulating inflammation depends. For this purpose rich foods, strengthening wines, and, in the case of tuberculosis, residence in a favorable climate should be recommended.

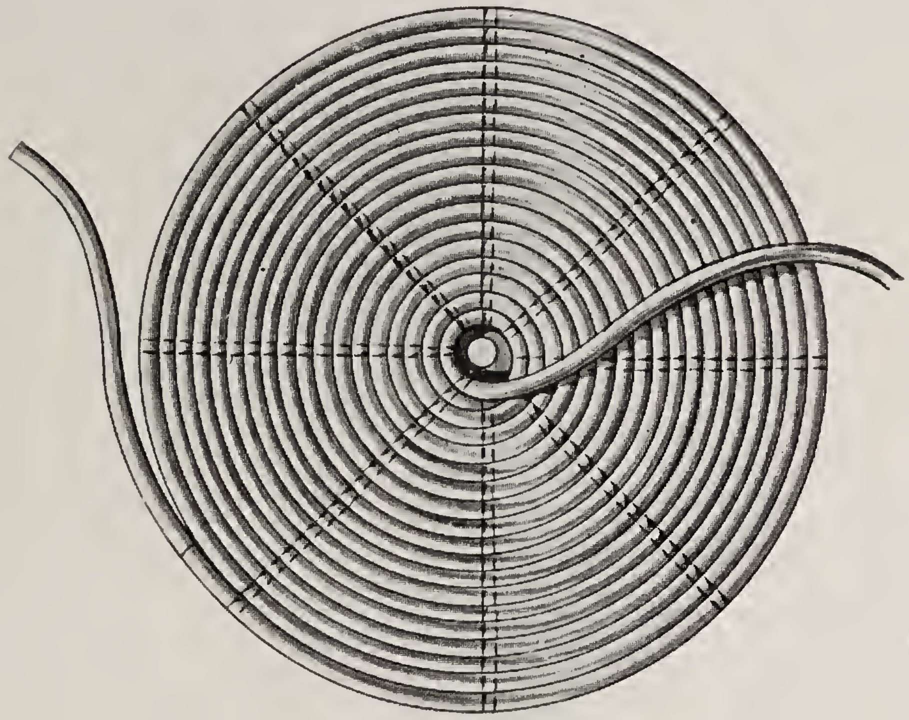

Fig. 17.—Ice-coil.

6

SECTION II

INJURIES AND DISEASES OF SEPARATE TISSUES

THE SKIN AND SUBCUTANEOUS CONNECTIVE TISSUE

CONTUSIONS AND OTHER TRAUMATISMS

Owing to the great elasticity of the skin, force applied to its surface by a blunt instrument or object may produce a solution of continuity of the underlying structures without producing separation of the skin itself. Crushing effects may also lead to rupture of vessels and extensive hemorrhage into the subcutaneous cellular tissue (**hematoma**) without apparent injury to the skin itself. The presence of long elastic fibers in the cutis and subcutaneous connective tissue will reasonably account for this power of resistance to injury which the skin possesses. Gaping of the wound when sharp-edged instruments are employed is also accounted for by this elastic property of the skin.

The arrangement and extent of the fibers of the skin are not the same in all portions of the surface of the body. In the extremities they pursue a course almost parallel to the limb; on the trunk they are irregularly distributed as regards direction, while about the palpebral fissure and margins of the oral opening they are disposed in a circular manner in accordance with the manner of disposition of the orbicular muscles. In fact, it is evident that the elastic fibers follow, to some extent, the direction of the muscular fibers of the part. The pectoralis major and latissimus dorsi show this plainly. The strictly longitudinal direction is not preserved in the case of the knee-joint and elbow-joint. Here the elastic fibers pass around the patella and olecranon in a concentric fashion.

Gaping of Wounds.—The manner in which solutions of continuity in the surface of the skin will gape depends, therefore, on the location of the wound and the direction in which it divides these fibers. If it is on an extremity and passes at right angles to the direction of the elastic fibers, there will be the maximum amount of gaping; while if it passes in the same direction as the fibers, the minimum amount will be produced; in the latter instance but few fibers are severed, as compared with the former. The proximity of the wound to a ginglymoid joint will likewise govern the amount of gaping. Tension on the convex side of the knee-joint or elbow-joint will tend to increase the separation of the wound edges. Wounds of the sole of the foot and palm of the hand are observed to gape but very slightly, for the reason that in these regions the fibrous structure of the connective tissue is so arranged as to form a dense attachment between the papillary body and the underlying aponeurotic structures. This will explain the difficulty which the surgeon experiences in turning back a flap in these localities as compared with one in other portions of the body.

The above considerations will enable the surgeon to estimate in many instances the amount of tension which it is necessary to make on the wound edges in order to bring about perfect approximation, as well as aid in the selection of a proper suture material.

Abrasions of the Skin.—In abrasions of the skin involving but little more than the papillary layer the reparative process takes place rapidly and pathologic inflammation does not occur. The injured layer of the rete Malpighii furnishes a few drops of blood and exudation, which, mingling together and undergoing coagulation, cling to the abraded surface. Evaporation of its watery elements leads to desiccation of the mass, and the typic crust or scab is formed. This serves as a means of protection to the underlying wound surface, and its rapid change from a moist to a dry state keeps it from becoming a favorable pabulum for bacteria, so that suppuration is prevented.

In this method of repair, called **healing under a crust,** there is complete development of the epidermal layer beneath the incrustation, when the latter, left undisturbed, is permitted to fall off of itself. This healing is possible in a natural way only in case there is but a slight amount of primary wound secretions and in situations favorable to rapid desiccation. Attempts to imitate the formation of the crust by artificial means have been more or less successful in wounds extending into the subcutaneous cellular tissue and involving blood-vessels and lymph-channels. Thus, asepsis being assured, the wound has been hermetically sealed by means of collodion, with or without the addition of iodoform (Küster), or some other antiseptic powder. The latter alone, provided it is sterile and the wound edges are brought into contact, is quite efficient. In fact, any occlusive method which shuts out from the wound extraneous and irritating matters imitates the process of healing under the scab.

Suppurative Inflammation of the Skin.—The skin may take on suppurative inflammation from infection having its origin in a wound. This is superficial in character and comparatively harmless, involving only the rete Malpighii and the papillary body. Owing to the dense character of the parts involved, rapidly progressive suppuration is impossible.

Suppurative Inflammation of the Subcutaneous Connective Tissue.—Here, without aseptic and antiseptic measures, phlegmonous conditions of a very severe character are easily produced. The arrangement of the elastic fibers in this situation, and the parallel direction of the lymph-current, form favorable conditions for the propagation of phlegmonous suppurative inflammation. It is not necessary, however, that phlegmonous inflammation of the subcutaneous connective tissue should have its origin in a wound involving this structure. A microorganism of sufficient infecting power in the rete Malpighii, which may have gained entrance therein by an almost microscopic breach of surface, may finally reach the subcutaneous connective tissue, where it propagates rapidly. So-called idiopathic phlegmonous inflammations are to be accounted for in this manner. The more or less constant coexistence of **lymphangitis** with subcutaneous cellulitis renders it probable that the course of the infection is along the lymph-channels. The simultaneous involvement of the papillary layer and rete Malpighii with the subcutaneous connective tissue constitutes the condition known as **erysipelatous cellulitis,** or traumatic erysipelas.

Losses of substance may occur in the skin in consequence of trauma, from sloughing as a result of the injury, or in very high grades of phlegmonous inflammation. Destruction of the skin likewise follows as an effect of extreme heat and cold (burn and frost-bite) and as a result of ulceration. In the repair which takes place the first essential is the proliferation of healthy granulations. These subsequently, by a process of contraction, approximate to some extent the margins of the granulating surface, and in this way the defect is partially corrected by the neighboring structures. While under these circumstances the displacement of neighboring tissues is of service in assisting to supply a defect caused by loss of substance, some very serious disadvantages may subsequently follow, as we shall see further on. In addition to the attempt at closure of the defect by cicatricial shrinkage, the **formation of an epidermal layer** is needed to complete the process of repair. This formation may take place rapidly or slowly, and the resulting epidermal formation may be a firm and solid layer, or may prove to be thin and defective, in which case further aid will be needed. This is furnished by either plastic procedures or skin transplantation (Reverdin, Thiersch) (see page 328).

THE CICATRIX AND ITS DISEASES

Although the complete cicatrix is intended to serve the purposes of the normal structure which it replaces, it is never identical, either anatomically or functionally, with the normal structures. When recently formed, it may break down and take on inflammatory conditions, particularly if aseptic precautions have been neglected during the healing process.

Abscesses in scar tissue may result from the presence of foreign bodies, such as bone spiculae, or portions of ligature or suture material. **Suppuration** from the presence of infectious agents may occur in the newly formed tissue. **Ulceration** may result from mechanic causes, such as friction from the clothing. In the recent cicatrix this may heal readily, but, later on, when the rich blood-supply disappears, ulcerative conditions heal but slowly. In addition, **injury** to the cicatrix may arise from its unyielding and inelastic character, solutions of continuity occurring more readily than in the soft and elastic normal structures.

Pain from pressure on nerve-trunks may result from the pressure of dense and extensive scar tissue. This will be severe and persistent according as the nerve-trunk or its sheath is actually involved in the cicatrix, or as it results from simple pressure or tension consequent on the shrinking of the cicatrix.

Cicatricial Keloid.—The causes of the degenerative changes in scar tissue, known as keloid, are obscure. Cicatricial keloid is characterized by increased vascularity of the scar, together with growth into the surrounding tissues, a tumor resulting which is very hard and has a reddish color. Extirpation followed by primary union, and even skin-grafting or transplantation, does not prevent recurrence. The disease, in this respect at least, resembles malignant disease. Electrolysis (Hardaway) and continued pressure by the elastic bandage (Verneuil) are recommended. **Multiple scarifications** made at intervals of a sixteenth of an inch from one another, crossed so as to form square or lozenge-shaped figures, deep enough to reach almost to the depth

of the growth and long enough to reach just beyond its borders, should be tried, local anesthesia being employed. The parts should be dressed at first with boric acid solution, and twice daily applications of mercurial plaster should be commenced on the day following. The scarification is to be repeated until the growth disappears. The application of the x-rays has been recently recommended.

Epithelioma of Cicatricial Tissue.—Recurrences in operation wounds following extirpation of malignant growths are not to be classed with the condition under consideration. True cicatricial carcinomas are to be divided primarily into two groups: (1) those having their origin in theretofore unchanged and typic cicatricial tissue; (2) those occurring in cicatricial tissue which has been the site of previously existing but benign ulcerative processes. The latter group includes the larger number of cases. The sites of old seton cicatrices, leg ulcers, bone fistulas and old urinary fistulas about the penis, scar tissue in the rectum and along the lower intestinal tract where dysenteric and old tuberculous and other ulcerative conditions have previously existed, and old parturient lacerations of the cervix uteri are favorite locations for the disease. It may occur on the granulating surface of cicatricial tissue which has never been covered with normal epithelium. The disease develops, as a rule, where the greatest amount of tension exists in the scar, when efforts are made to reduce deformities due to the latter, and at the site of ulceration from injury. Applications to the latter of nitrate of silver or of other cauterizing agents may contribute toward the result. It inclines to spread on the surface, and rarely passes into the depths of the tissues; when the latter condition occurs, an extremely malignant form of the disease is present. The **treatment** consists in early and radical extirpation. Amputation of an extremity offers a better prognosis than ablation of the ulcer and its surroundings. Primary union should be obtained; existing defects should be corrected at once by accurate coaptation and plastic procedures when necessary.

ULCERATION OF THE SKIN

By ulceration is meant that process in which the tendency to progressive suppurative destruction of tissue is greater than the tendency to granulation. The resulting condition is called an **ulcer.** Ulcers may be divided into three groups. The first includes those which arise from disturbances of the circulation. The second embraces those in which an ulcerative process is engrafted on a granular inflammation (syphilis, tuberculosis, leprosy). The third is composed of cases in which an ulcerative condition supervenes in certain neoplasms, notably those of a malignant character. In the first group the vascular error may be (1) a local anemia arising from some interference with the arterial current; (2) a local congestion due to interference with the return circulation. A slight traumatism or an eczematous vesicle, through which irritating or putrefactive agents have entered, may give rise to an ulcer, repair or the formation of normal granulation tissue being rendered difficult by the disturbances of the circulation. Besides the ulcers which occur in conditions of enfeebled circulation and varices, **varicose ulcers** may arise from inflammatory conditions involving the dilated veins themselves.

Ulceration from Pressure; Bedsores.—A necrosis of portions of tis-

sue that have been exposed for a considerable time to pressure, occurring in those lying in bed, or in certain paralyses of cerebral or spinal origin in which the pressure is neither considerable nor prolonged, constitutes the classic type of ulcer known as bedsore or **decubitus.** The position of these bedsores will vary with the position of the patient. They are usually confined to the skin overlying projecting bony points. In the dorsal position the sacrum, coccyx, and tuber ischii are the most prominent points. The skin over the spines of the scapulae, the occiput, and, in the lateral position, the trochanter major and the malleoli may suffer. If the patient lies on the abdominal surface, bedsores may appear on the anterior superior spinous processes of the ilium, chin, and forehead. Pressure of the bed-covering alone may produce bedsores, the extremity of the toes and the prepatellar regions suffering. Fever is a predisposing cause of bedsores; with the subsidence of the fever the ulceration may take on a healthy action or heal entirely, only to recur upon relapse.

The appearances present when a bedsore is about to occur are characteristic, consisting of a reddish discoloration of the skin at the point of pressure, followed by a bluish tint which afterward changes to brown or black. The resulting destructive process involves the entire thickness of the skin, and even the underlying structures to the bone. A suppurative and putrefactive process occurs coincidentally in some cases; in others, after a longer time more or less oval or round defects of tissue are produced, which, in some instances, are never restored, and in others occupy months in the healing process.

The **treatment** of the class belonging to the first group of ulcers, arising from disturbances of the circulation (**varicose ulcers**), consists (1) in correcting as far as possible the disturbed conditions of the circulation on which the ulcer depends; (2) in affording even and firm support to the vessels of the part, in order to minimize as much as possible the tendency to stasis. Elevation of the limb, with the patient in the horizontal position, whenever this is possible, is of material service in fulfilling the first indication, and systematic strapping and bandaging fulfil the second. In carrying out the latter, all antiseptic conditions should be complied with. Thorough shaving and scrubbing of the neighborhood, and irrigating with sublimate solution, should precede the application of the strapping. In case a hard elevated ridge circumscribes the ulcer, or a dense fibrous floor exists, it will be necessary first to incise these thoroughly in order that the vessels beyond and beneath the area of the ulcer may be permitted to find their way into the latter and convey suitable nourishing material for the purpose of repair (L. A. Sayre). These incisions should be made about a quarter of an inch apart, in the direction of the long axis of the limb, and should penetrate well through the hard fibrous floor above mentioned. An anesthetic is not necessary, under ordinary circumstances, as the incisions can be rapidly made, and the parts, as a rule, are not very sensitive. Bleeding having ceased, whatever blood remains on the surrounding skin should be carefully wiped away by means of a bit of dry sterilized gauze, while any clots which cling to the edges of the incision or remain on the ulcerated surface should be left undisturbed. These blood-clots will form an arbor or trellis-work, through the medium of which the surrounding and underlying vessels, which now have access from the cut edges of the incisions, will penetrate and form new

granulation material. The circulation in the foot should be supported by either a snug flannel bandage or circular strips of adhesive plaster, systematically applied. These may reach to within about two inches of the edge of the ulcer. The ulcer itself is to be strapped in so-called "basket strapping." This consists of strips of diachylon or resin plasters, cut in lengths about one inch less than will be sufficient to encompass the limb and not more than one inch wide. When practicable, it is better to cut the strips crosswise to the piece as it is furnished by the manufacturer. This facilitates their smooth application. Each strip, at the moment of application, is heated over the alcohol lamp. This sterilizes the surface which is to be applied to the ulcer, and at the same time increases its adhesiveness. The first strip is applied horizontally, and just overlaps the upper boundary of the flannel bandage; it encircles the limb. The next strip is placed vertically, or at right angles to the above, and is likewise placed at least two inches from the nearest border of the ulcer. The next strip is placed horizontally, and half overlaps the first. The next or fourth strip is placed vertically and half overlaps the second, or the vertical strip which has preceded it. The process is now continued in the same manner, alternate horizontal and vertical strips being applied until the entire surface of the ulcer is gradually covered. (See Fig. 18.) The strapping is carried well above and beyond the margins of the ulcer. An antiseptic compress, made of crumpled gauze and large enough to cover and overlap the plaster strapping, is now placed over the latter, and over all, including the flannel bandage of the foot, a roller bandage is firmly applied. Should no discharge or other evidences of disturbances occur, the dressings should be allowed to remain for from ten to fourteen days; the patient, as a rule, is permitted to walk about. At the end of this time the bandage and plaster are to be slit up with a pair of bandage scissors, care being taken in doing this to select a point sufficiently far from the site of the ulcer in order to avoid injuring this with the scissors. The bandages and plaster are now removed, the latter peeling off like the bark of a tree. Some tenacious secretion from the ulcerated surface will be found on the plaster, as well as on the neighboring skin. From the latter situation it may be removed with a piece of sterilized gauze; on no account should

Fig. 18.—Basket Strapping and Ulcer of the Leg.
A, Bandage applied to foot and ankle; B, basket strapping; C, portion of ulcer remaining uncovered; D, incisions through base and edges of ulcer.

the gauze be permitted to come in contact with the ulcer itself. In lieu thereof a gentle stream of a mild antiseptic solution (boric acid 1 : 1000) should be allowed to flow over the surface of the ulcer until it is thoroughly cleansed. A striking change will be found to have taken place in the ulcer. In place of the hard and elevated edge, which will be found to have disappeared, there is a soft flattened margin, from which a white or pale blue line of new epidermis is already forming. The hard and smooth floor will have given place to a bed of soft and healthy granulations. The incisions, where they cross the margins, gape widely and are filled with healthy granulations. The antiseptic solution is not to be dried from the surface of the granulation; only the surrounding skin is to be dried. Precisely the same course is now followed as at first.

It may happen that the first dressings will need replacing before the time specified above, owing to the occurrence of discharge through the bandage; it is rare, however, that a bandage cannot remain on at least a week. Two or three dressings, except in exceptionally large ulcers, usually suffice, when the epidermal layer is found to have completely covered the granulating surface, and the cure is complete. The patient should thereafter, in order to escape relapse, wear a silk elastic stocking to support the circulation in the part, care being taken in the beginning to place a piece of soft linen or lint over the newly formed cicatrix in order that this may not become irritated and renewed ulceration occur. In case of the latter the skin-grafting method of Reverdin or that of Thiersch should be employed. (Plastic operative procedures, skin transplantation, etc., will be described under the head of Operations on the Skin.) Although chronic ulcers of the extremity are far more amenable to treatment now than formerly, there are still cases which are intractable, suggesting malignant disease. Still others extend deeply and involve the periosteum, necrosis resulting. In these cases, as well as in some instances which involve the entire circumference of the leg (circular ulcer), other measures failing, the resort to amputation is justifiable.

Treatment of Bedsores.—Early measures should be taken to prevent ulceration from pressure in the sick and disabled. This may be accomplished, in the majority of cases, by the judicious use of elastic cushions to distribute pressure, by occasional bathings with alcohol and water, and by the use of ring-shaped air or water cushions, when ulceration threatens or is in progress. An occasional change of position will likewise be useful. When ulceration occurs, this should be treated antiseptically, with 1 : 1000 sublimate solution, after which the ulcerated surface should be powdered with naphthalin and iodoform in equal proportions and dressed with antiseptic gauze. The resulting separation of sloughs may be hastened by the vigorous use of the curet. Healthy granulations follow as a result of this treatment, and, these once established, the use of iodoform gauze or Peruvian balsam and naphthalin gauze as a dressing will result, in most cases, in final healing. Occasionally iodoform ointment or Peruvian balsam on gauze is found to be a useful dressing. Various astringents, such as nitrate of silver, chlorid of zinc, or preparations of lead, are also employed, as well as some of the mercurial ointments, particularly a diluted ointment of the red oxid of mercury. An exceedingly valuable combination consists of 1 part of nitrate of silver, 5 parts of Peruvian balsam, and 20 parts of simple ointment. Sometimes

considerable time may be saved by freshening the edges of the ulcer, detaching the soft parts for some distance beyond the edges, and bringing the margins in more or less close approximation by silkworm-gut or silver wire sutures. After preliminary curetting and antiseptic treatment, filling the ulcer cavity with a blood-clot obtained by scarifying the granulations, and dressing by means of oiled silk protective and antiseptic dressings (the so-called healing by organization of the clot, Schede), or sponge grafting, has proved of service. Finally, these ulcers, like those on the leg, may be treated by a circumscribing incision (Nussbaum), incision of the boundaries and floor, and by skin transplantation.

EFFECTS OF HEAT AND COLD

Certain physical and chemic disturbances occur alike as the result of excessive heat and cold. The inflammatory conditions present are not essential but accessory. These disturbances consist of changes in the skin and circulating channels, which vary according to the temperature and length of time of exposure of the part.

Degree of Burns.—A momentary exposure to a temperature at or just below the boiling-point of water produces a simple paralysis of the constrictor muscles of the smaller arteries, and a consequent overfilling of these. The increased quantity of blood which results from this occasions the redness observed under these circumstances; this is known as a **burn of the first degree. Burns of the second degree** are those in which blistering takes place, the parts being exposed for a greater length of time or to a higher temperature. Here there is an exudation of serous fluid into the tissues, and particularly into the rete Malpighii; portions of the epidermal layer are lifted up, constituting the covering of the blister. More lengthy exposure to the temperature of boiling water induces albuminous coagulation affecting the contents of the vessels, together with the serous fluid and albuminous substances of the tissues. Owing to this interference with the normal structure, greater or lesser areas are deprived of nourishment, and hence **necrosis of tissue** constituting a **burn of the third degree** is the result. The dead tissue presents a white appearance from coagulated albumin. In case of exposure to a still higher grade of heat, as, for instance, on the application of a glowing hot iron, the destroyed tissue may assume a blackish tint. Some authors make a fourth and even a fifth degree of burn. These are, however, simply the third degree exaggerated, and constitute charring either of the skin or of this and the muscular structures as well.

Prognosis of Burns.—The involvement of large areas of the surface in burns of the second and third degree involves direct danger to life. Burns of the first degree in very young children may, even if of but limited extent, prove fatal. Still smaller areas of the second and third degree may also result fatally. Mere reddening of more than two-thirds of the body, or a burn of the first degree, in an adult may destroy life, while one-third of the surface burned to the second or third degree will almost inevitably produce death. Locality will to some extent govern the prognosis. A lesser area in the abdominal and thoracic regions is to be regarded more seriously than a larger extent of surface on the extremities. Death may result directly

from shock. Overstimulation of the superficial sensory nerves may produce death by reflex cardiac paralysis (Sonnenburg). After reaction, congestion of internal organs from vasomotor paresis may occur; it is probable, however, that excessive destruction of the red blood-corpuscles and their conversion into small globules (Max Schultze) are more frequently the cause of blood-stasis in internal organs. The secondary dangers relate to prolonged suppuration, exhaustion, erysipelas, pyemia, septicemia, and tetanus. Perforating ulcer of the duodenum has been observed as a secondary complication of burns. **Edema of the glottis** from scalds of the mouth is an occasional fatal complication.

Excessive Cold, or Frost-bite.—When the temperature of the skin is considerably lowered, the constrictor muscular apparatus of the small arteries contracts. If this occurs suddenly, the blood is shut off from the respective areas of distribution, and a blanching of the surface is observed as a result of the local anemia. This is seen in the ear and nose when exposed to a low temperature. As a rule, however, this takes place slowly, and the flow of blood through the parts continues, though imperfectly. In affected regions remote from the center of circulation greater difficulty is experienced by the heart in forcing the blood into the larger veins, and hence in these parts (the hands and feet) the earliest and most destructive effects of frost-bite are observed. In the venous stasis which marks the **first degree of frost-bite,** the discoloration, unlike the redness in the first degree of burns and scalds, is of a bluish tint. This difference arises from the fact that, in the case of a burn, the redness is the result of an arterial flux, while, on the other hand, the discoloration in the first degree of frost-bite results from venous stasis. The **second degree** of frost-bite is characterized by the formation of small vesicles. If the lowered temperature of the parts persists, the resulting stasis forces the blood-serum from the capillaries and smaller veins. This accumulates in the rete Malpighii, and, elevating here and there the horny layer of the epidermis, results in the formation of blisters. Unlike the vesicles resulting from burns, these are filled with straw-colored fluid or reddish liquid, due to the presence of red blood-corpuscles in greater or lesser number. In the **third degree** of frost-bite, like that of burn, more or less destruction of the skin by necrosis occurs. A persistent venous stasis is followed by gangrene, which differs in color from that following a burn. In the latter, the skin assumes a white appearance from albuminous coagulation, or a black hue from actual carbonization or charring. In the third degree of frost-bite the color of the necrotic portion is dark brown. This arises from the fact that, owing to the venous stasis, a large amount of blood-pigment is imprisoned in the part as gangrene takes place. Later on, as putrefactive changes occur, this dark brown color deepens into black.

Prognosis of Excessive Cold, or Frost-bite.—Excessive cold endangers life in proportion to the length of time of exposure and the extent of surface involved. Muscular rigidity alone may produce death. The most important factor in producing immediate death, however, is the destructive changes which the blood-corpuscles undergo, exposed, as they are in venous stasis, for a long time to the effects of excessive cold. In consequence of these changes they lose their function as oxygen-bearers. It is probable also that when a large mass of blood-corpuscles thus altered is permitted to enter the general cir-

culation, the frozen part being too rapidly restored, the blood-corpuscles may accumulate in internal organs and exert a deleterious influence on the entire economy. This is a rational explanation of the fact that, in persons who have been exposed to excessive cold with resultant frost-bite, the frozen parts cannot be subjected to the action of heat without great risk, but must be treated rather by cold applications, such as friction with snow or ice-water in a cold room, the change to a warmer atmosphere being brought about gradually. Thus the whole mass of altered blood-corpuscles is not at once precipitated into the circulation, but rather admitted gradually.

Inflammatory Conditions Following Burns and Frost-bite.—**Burns of the first degree** somewhat resemble in appearance an inflammation of the structures affected. But the differences become apparent when it is observed that the former disappear spontaneously after a very short time. In burns of the **second** and **third degrees,** however, opportunities are afforded for the entrance of microorganisms. In the former, if the vesicles are not disturbed healing may take place beneath the raised outer layer constituting the surface of the blister. Usually, however, these are ruptured, and more or less infection takes place as a consequence, inflammatory complications following. In burns of the **third degree** the infection does not, as a rule, take place in the area of charred tissue, since here the usual and readiest channels of infection are closed, but from the margins of the burn, which, as a rule, are not carbonized, but the seat of a burn of the second degree. At this point a slowly progressive suppurative inflammatory process goes on, the neighboring structures partaking of this to a greater or lesser extent; this is what is known as the **suppuration of demarcation,** and marks the site of the so-called **line of demarcation.** By means of it the necrotic tissue is slowly lifted and separated from the living structures beneath. A phlegmonous inflammatory condition may replace the suppuration, in which case the line of demarcation is not formed at the site of the original injury, but an inflammatory necrosis may become associated with that arising from the burn; in this way larger areas of tissue become involved in the gangrenous process. With the early employment of antiseptic measures, however, the suppuration of demarcation is not always observed. The charred portion does not form a favorable soil for the development of bacteria, owing to the coagulation of its albuminous elements. If, therefore, the entrance of bacteria can be prevented at the margins, the entire separation of the necrotic portion may occur without any trace of suppuration. The white blood-corpuscles do not migrate; new vessels are formed, and, the young vascular connective tissue crowding toward the necrotic tissue, an aseptic granulation process takes the place of the suppuration of demarcation.

Similarly, in the **first degree of frost-bite** true inflammatory conditions are not present. Even though increased heat is present as a result of reaction the arterial flux is soon replaced by the normal state. But the vesicles which form in **frost-bite in the second degree** may become the medium of infection and subsequent inflammation may occur, precisely as in burns, though not so readily nor to the same extent. The occurrence of **chilblain or pernio,** however, is common, particularly about the fingers or toes, as well as about the nose, ears, and lips. This is usually induced by the patient's coming too suddenly in contact with warm air after frost-bite, and is particularly liable to occur in children and feeble persons.

Frost-bite of the **third degree,** however, offers the conditions favorable to the rapid occurrence of infection, and hence of inflammation. Unlike a burn of the same degree, the tissues are filled with blood in a passive state, the albuminous elements are not coagulated, and the necrotic tissues offer the three cardinal conditions favorable to germ proliferation and putrefaction, namely, warmth, moisture, and putrescible organic matter. The surrounding zone of venous stasis offers a fertile field for bacterial invasion and proliferation, together with rapid death of the parts. These in their turn undergo putrefaction, and thus the progressive gangrene extends a considerable distance beyond the apparent area originally involved in the frost-bite. Unless, therefore, an early antiseptic course is followed in the treatment, extensive and severe septic conditions may complicate the original frost-bite. Finally, a line of demarcation may occur here as in the gangrene following burns of the third degree, and the same process of elimination of the dead parts may take place.

Burns of the second and third degrees involving movable parts are frequently followed by deformities resulting from subsequent contraction and shortening of the cicatrix. These are particularly distressing when occurring in the facial region, where they are greatly increased by the involvement of the platysma myoides, the anterior portion of the neck and the upper portion of the chest, and in the flexures of the joints.

The Treatment of Burns and Frost-bite.—As far as the **immediate** treatment of burns and frost-bite is concerned, inasmuch as inflammatory conditions are not necessarily present, the employment of antiphlogistic agents is useless. The influx of blood to the parts in the burn soon disappears, and the coagulation and exudation are alone to be considered. In frost-bite, however, the venous stasis is more permanent, and measures to support the venous circulation, if an extremity is affected, are indicated. In addition to this, **chilblain or pernio,** which may follow frost-bite of the first or second degree, is to be treated. This may amount to a chronic stasis, for which warm baths may be useful to hasten the venous circulation. Again, **friction with snow or ice-water** will be found serviceable. **Liniments** containing oil of turpentin, diluted hydrochloric acid (4 : 100), or the applications of collodion are useful in this condition. A favorite stimulating application consists of tincture of cantharides one part, and soap liniment three parts (W a r d r o p). When itching or burning sensations are prominent symptoms, a 2.5 per cent solution of carbolic acid, to which is added tincture of opium in the proportion of an ounce to the pint, will procure relief. In chronic cases in which the skin becomes thickened, equal parts of the tincture of iodin and glycerin may be employed. Oil of peppermint, pure or diluted with six times its bulk of glycerin, is also successfully used. In chronic cases, or those which have a persistent tendency to recurrence, the galvanic current has been advantageously employed. In the mild and superficial forms of **ulceration** which may follow chilblain, the employment of a carbolic acid or creosote ointment, or other combined antiseptic and stimulating application, will be indicated.

In cases of burns as well as in those of frost-bite, where the slightest vesication occurs, the practitioner should bear in mind, as the first indication for treatment, the necessity for early aseptic and antiseptic measures. The extent and severity of the resulting inflammatory complications will be in direct

proportion to the amount of infection which occurs. The old-fashioned methods designed to shut out the atmospheric air, such as dusting the parts with flour, or covering them with wadding with or without the employment of oily compounds, were useful in that they prevented to some extent bacterial infection and, by promoting rapid drying of the exudates, deprived the micro-organisms of material favorable for their support and proliferation. The use of equal parts of lime-water and linseed oil (carron oil) also acted by affording protection. These may, however, be profitably replaced by antiseptic irrigation, followed by the application of antiseptic dressings, both to the vesicles which are still entire and to those which have been accidentally opened. Antiseptic powder dressings (iodoform, zinc oxid, bismuth subiodid, etc.) may be employed, with or without the addition of gauze material impregnated with the same. Supporting measures and remedies designed to relieve pain in severe cases form necessary adjuncts to the treatment.

In cases in which extensive and deep gangrenous areas are present, involving, for instance, a considerable portion of a limb, **removal by amputation** will become necessary. The **dissecting away of sloughs,** in order to get rid of putrefying masses as rapidly as possible, is always indicated, and should be practised wherever feasible for this reason, as well as for the purpose of obtaining access to the parts beneath for more thorough antisepsis. In making antiseptic applications to extensively denuded or large granulating surfaces the poisonous character of some of these agents should be borne in mind. When wet dressings are indicated the borosalicylic solution of Thiersch (page 61) should be employed. For a dry dressing either salicylic gauze or oxid of zinc gauze is useful. With the clearing away of the vesicles and sloughs an ointment dressing best fulfils the indications. Boric acid ointment, or an ointment consisting of dried alum (50 parts to 450 parts of the vaselin and paraffin base, page 62), Peruvian balsam, ichthyol, and carbolic acid in proper proportion should be used.

FURUNCLE, CARBUNCLE, ANTHRAX, AND GLANDERS

Furuncle.—A furuncle or boil is a circumscribed inflammation of the skin, characterized by a typic course. It is caused by a coccus, probably Staphylococcus pyogenes aureus, which reaches the roots of the hair by penetrating along the sheaths of the hair-follicles from the deep epidermal layer. Its appearance is, therefore, restricted to regions in which hair grows, and it attacks by preference those portions of the body that are particularly exposed. Certain anatomic peculiarities will likewise predispose to the production of these cocci. In some individuals the openings of the sheaths of the hair-follicles are larger than in others, and in certain portions of the body the same difference exists. If the cocci do not penetrate beyond the mouth of the follicle, only a pustule is formed. In the majority of cases, if they pass beyond the mouth of the follicle, a true furuncle results. Under these circumstances a violent inflammation follows, characterized by necrosis of the hair-follicle and the surrounding connective tissue. A circumscribed red swelling of the skin appears, the center of which is occupied by the affected hair-follicle. A varying amount of necrosis follows, and constitutes what is known as the core. A furuncle may occasionally invade the

subcutaneous cellular tissue, in which case a phlegmonous inflammation may result.

Carbuncle.—A carbuncle is a circumscribed inflammation of the skin occupying a larger area than the boil or furuncle, and results from the extension of infection from one hair-follicle to a number of others in the neighborhood. Or it may, after commencing as a comparatively superficial inflammation, extend to the subcutaneous connective tissue. It more commonly attacks the thick skin at the **back of the neck** and in the **upper dorsal region,** in which regions the hair-follicles are arranged in groups and their sheaths pass deeply into the subcutaneous connective tissue. The rigid connective-tissue fibers in these regions so interfere with the circulation on the access of inflammation that a venous stasis occurs. This gives to the swelling a bluish tint. The sloughing process begins in the subcutaneous connective tissue and extends thence to the surface, the latter breaking down at several points at once and giving the mass a honeycombed appearance. The **gluteal region** may be attacked by carbuncle. Here the extension may be considerable in the fatty solid connective tissue of the part, and large flat swellings may occupy comparatively large areas without producing a proportionate amount of elevation of the surface. Sloughy masses of connective tissue of considerable size are present in carbuncle in this region.

In the course of **diabetes mellitus** carbuncles are liable to appear. A reasonable explanation for the frequent combination of diabetes and carbuncle has not as yet been found. Under these circumstances carbuncle not infrequently proves fatal. Carbuncle may likewise threaten life in comparatively healthy persons who have no general disease. The prognosis is graver when it occurs in elderly people, and likewise when erysipelas or phlegmon arises as a complication. Death may occur from phlebitis and septic emboli (pyemia), or from exhaustion or septic pneumonia.

Anthrax.—The occurrence of a carbuncular process about the lips, cheeks, and forearms or dorsum of the hands should at once excite suspicion of anthrax, a disease originating in oxen and sheep, and especially liable to occur in those handling the dried hides of these animals. This suspicion will be strengthened if the gangrenous process forms and spreads rapidly. An examination of the affected tissue, if this disease is present, will reveal the presence of the **anthrax bacillus** (see page 30).

Glanders.—This is a contagious disease occurring primarily in horses or in asses and mules. It is characterized in these animals by an ulceration of the mucous membrane of the nose, swelling of the submaxillary glands, and suppurative metastases in internal organs. It is capable of being transmitted to certain other of the lower animals, and to man as well. The infection usually takes place through some small abrasion, though this may occur through the hair-follicles. At the point of entrance of infection there appear small ulcers with sharp edges, which secrete a thin pus. These may be on any point of the skin usually exposed, or on the mucous membrane of the nose or on the conjunctiva. Extensive inflammation of the superficial structures first attacked, together with inflammation of the underlying connective tissue, results. This inflammation may follow the course of the lymph-channels. Pustules or nodules appear, which break down into ulceration and discharge pus; more or less extensive abscesses may follow, and

large vesicles containing thick mucus-like pus may form. These vesicles and pustules, on discharging, break down with a tendency to phagedena, and are characteristic of the disease; they mark the occurrence of general infection. Similar lesions may occur in the respiratory passages, muscles, etc. Even the bones and joints may become involved. The specific microorganism (Bacillus mallei) somewhat resembles the Bacillus tuberculosis. It is sometimes found in the blood, but oftener in the foci formed by the nodules.

The Treatment of Furuncle, Carbuncle, Anthrax, and Glanders.—In the **treatment of furuncle** early and free incision is of the first importance. This permits antiseptic applications to the parts, particularly if followed at once by the use of the sharp spoon or curet in those cases in which necrosis has occurred. The application of a 5 per cent solution of carbolic acid or of a 1 : 1000 sublimate solution at once arrests the infection. Warm compresses of either of these solutions, covered with either oiled silk or rubber tissue, are of service. If pointing has already occurred, free incision, followed by curetting and packing with gauze wet with the sublimate solution, and covered with the wet compress and impermeable covering, is an admirable measure and calculated to afford immediate relief.

In **carbuncle** a most vigorous course must be pursued from the very start in order to limit the infection and resulting slough as much as possible. A number of parallel incisions or free crucial incisions are to be made, or, better still, complete excision of the underlying mass practised, the four corners of the skin resulting from the crucial incision of the older authors being turned back in four flaps for this purpose (Riedel). By this means a dangerous inflammatory focus is removed, the local and general infection is arrested in its progress, and rapid healing follows. The resulting cavity is to be treated with pure carbolic acid, which, after the lapse of two minutes, is washed away with alcohol, and a packing or tampon of iodoform or sublimate gauze applied. A wet compress of the latter, and a covering of impermeable material, as in the case of the furuncle, complete the dressing. A 50 per cent solution of zinc chlorid may be used in place of the carbolic acid, and gauze wrung out of a 25 per cent solution of the latter in glycerin used as a dressing until the infection is arrested. Ordinary stimulating dressings will then suffice.

In **carbuncles arising from anthrax infection** the same vigorous measures are employed. The thermocautery of Paquelin, however, should be substituted for the carbolic acid or zinc chlorid application following either crucial incision or extirpation.

A similar energetic procedure is indicated in **glanders.** The bacillus of this disease is readily killed by the application of heat, as well as by the sublimate solution.

GRANULAR INFLAMMATION OF THE SKIN AND SUBCUTANEOUS CONNECTIVE TISSUE

Tuberculosis of the Skin.—This is by far the most common form of granular inflammation of the skin. It may appear in the form of (1) lupus; (2) tuberculous ulcer; (3) the so-called cadaver or anatomic tubercle.

Lupus was formerly classed among the scrofulous diseases. In 1874 it

was suggested that it was a local tuberculosis (Volkmann, Friedländer). Soon after Koch's discovery of the Bacillus tuberculosis this microorganism was demonstrated in lupus. It is not always easy, however, to identify the microorganism. The disease attacks by preference young adults, though it may attack those in advanced years. It most frequently affects the skin of the face. Rarely it is found on the mucous membranes. Generally, when present on the latter structure, it advances from the direction of the skin. Occasionally it is seen on the hand, forearm, arm, and breast. It may appear in more than one place in the same individual. The disease was formerly classed among the tumors, but its inflammatory character is manifest from the suppurative and ulcerative destruction of the granular masses. The tendency of the disease is to remain local; rarely, however, it may lead to general tuberculosis. The variety known as **lupus vulgaris** is most frequently seen on some portion of the nose or eyelids. The course of the inflammation is essentially chronic, making its first appearance as brownish-red nodules which break down into ulceration and slowly coalesce. In the nose and eyelids the cartilages may become involved, and the nasal bony structure as well. As long as the skin structure alone is attacked there is a tendency on the part of the ulcerated surface to cicatrize, while at the same time in one or another direction fresh nodules make their appearance, which in their turn pass through the same processes. In this way a considerable area may become involved, in some portions showing the whitish scar tissue, in others the elevated nodules, while in others, again, an ulcerative destruction is in progress. The cicatrized surface is frequently covered with scales of thickened epidermis which repeatedly exfoliate. When the ulcerative process extends beyond the thickness of the skin and proceeds more rapidly than cicatrization, the disease is known as **lupus exedens.** In cases in which the granular proliferation is a marked feature, it is known as **lupus hypertrophicus.** The variety characterized by scaling of the epidermal layer is known as **lupus exfoliatus.** All three varieties may be present in the same individual.

The **differential diagnosis** of lupus and carcinoma of the skin is made by attention to the following points: (1) the peculiar condition of the ulcerated border and the nodules at and beyond this; (2) the tendency on the part of lupus to **cicatrize in one portion,** while fresh nodules break down in others, as compared, in carcinoma, with the progressive tendency to spread in all directions. Some difficulty may arise in cases in which carcinoma develops at the site of an old lupus. This occurs rarely on the face, but may take place on the dorsum of the foot or hand. Lymphatic involvement may be present in either disease. **Lupus exfoliatus** may at first glance resemble a dry eczema, but it is to be differentiated from the latter by the fact that in lupus the scaly formation is formed on cicatricial tissue, while in eczema there is no cicatricial formation.

The **prognosis of lupus** will depend on the extent of the surface involvement and the depth to which it penetrates. As before stated, it rarely gives rise to general tuberculosis, though this danger is not to be lost sight of. The functional prognosis, however, is important; extensive and extreme deformities may result from its presence, equaled only by the cicatricial shrinking resulting from burns.

The **treatment of lupus,** owing to the fact that the disease depends on a specific bacillus, will be, as far as possible, in the line of radical measures to effect its complete destruction and removal. This is accomplished by means of the sharp spoon. The entire area involved is thoroughly scraped and stimulating applications employed in the after-treatment. A more satisfactory method, however, consists in total excision of the diseased area and the subsequent transplantation of strips of skin after the method of Thiersch (Senger). This, together with rhinoplastic and cheiloplastic procedures, will be described in connection with special operative procedures. The use of the thermocautery and galvanocautery has been advocated; the influence of heat, as in certain galvanocautery operations about the uterus (John Byrne), is believed to extend beyond the area of the part to which the cautery iron is actually applied, destroying in the neighboring tissues the noxious agents which produce the disease. The use of the *x*-ray, as well as of Finsen's light, has proved effective in lupus and in the superficial carcinoma for which it may be mistaken. These are likewise recommended to prevent recurrence after radical operations for the cure of these conditions.

Certain chemic corrosive substances, such as the zinc chlorid (10 to 20 per cent), may be useful in certain cases. Nitrate of silver is too superficial in its effects, and tincture of iodin, sometimes recommended, is applicable only to the most superficial varieties of the affection. The application of caustic alkalis, such as caustic potash, is to be deprecated for the reason that the resulting slough is moist in character, and hence forms a putrefying mass in which microorganisms proliferate and extend into the surrounding structures, producing violent inflammation. The use of chlorid of zinc, carbolic acid, nitric acid, etc., by coagulating the albuminates, produces a dry eschar which is more easily maintained aseptic. This point may be borne in mind with advantage in the application of caustics in affections other than lupus.

Tuberculous ulcer is the result of a breaking down of a **tuberculous gumma.** The latter affects primarily the subcutaneous connective tissue. The neck, chest, and extremities are favorite locations for its appearance. The gumma consists of a painless swelling of varying sizes, which pursues a chronic inflammatory course and shows constant tendency both to form granulation tissue and to break down easily into ulceration. The involvement of the integument gives this a bluish or a reddish tint just prior to ulceration. When this takes place, one or more small openings may lead down to the mass of granulation tissue beneath. The skin structure is loosened from the latter by a process of suppurative inflammation, and the ulcer presents one or more openings in the skin, with overhanging, thin, livid edges. When these openings are enlarged, there may be seen through them the irregular surface of the mass of granulation tissue beneath, presenting the classic picture of a tuberculous ulcer. This may occur at the site of a lymphatic gland, in which case it is difficult to decide whether the gland or the skin and the underlying structure were the site of the primary infection. The affection may be associated with tuberculosis elsewhere. The **treatment** consists in dissecting away the overlying skin, in curetting the granulation tissue, and in applying vigorously to the surface zinc chlorid in 10 per cent solution (Lannelongue). Camphorated naphthol (Perrier) is

strongly recommended as an antituberculotic agent, as well as iodoform (Billroth, Mikulicz), and Peruvian balsam and cinnamic acid (Landerer).

The so-called **cadaver tubercle**, or **anatomic tubercle,** is a granular inflammation occurring as a flattened nodule on the backs of the fingers and hands of anatomists and their assistants, and is now recognized as a distinctly tuberculous affection, though some doubt is still expressed as to its exclusive origin from tuberculous infection. Other agents, particularly ptomains, give rise to similar nodules. They resemble plaques of lupus hypertrophicus, and vary in size from a pea to an almond. They may occur in clusters or singly, and their favorite site is the dorsal surface of the metacarpophalangeal joints. Erythematous patches and pustules may likewise appear. Though cadaver tubercle rarely becomes purulent, and scarcely ever gives rise to extensive inflammation of the connective tissue and of the lymph-channels and glands, yet the nodule should be thoroughly removed, either by excision or by application of the thermocautery.

Syphilis of the Skin.—From the viewpoint of the general surgeon, the two most important lesions of the skin occurring as the result of syphilis are (1) the syphilitic initial sclerosis ; (2) the syphilitic gumma of the subcutaneous connective tissue. The **initial lesion** of syphilis, as its name implies, is the first manifestation of the presence of the disease, as far as is at present known. It occurs at the point where the infection makes its entrance, and occupies from ten to thirty days in its development after the date of infection. The sclerotic nodule, when first noticed, is usually about the size of a pea. The center of the infiltrated part breaks down into an ulcer, the edges of which, as well as the base, being formed of granulation material, retain their characteristic hardness. This constitutes the classic so-called **Hunterian** or **hard chancre.** It may happen that a **soft chancre,** or **non-syphilitic venereal sore (chancroid),** resulting from contact with indifferent or not necessarily specific organisms, may follow within a day or two after exposure, which, pursuing the course of such ulcer up to a certain point, may thereafter present the symptoms of genuine syphilitic chancre. Here the syphilitic local infection follows the usual course of incubation of from ten to thirty days, the indifferent or nonspecific infection producing its local effect at once. It may happen, on the other hand, that a primary sclerosis may occur, which never breaks down into ulceration, but, after running its course as a granulating infiltration, disappears.

The location of the initial sclerosis varies, but, as a rule, it occurs on the genitals. Exceptionally, it has been found within the oral cavity, on the tonsils, and on the end of the nose. Nonvenereal syphilitic chancre may occur on the surgeon's fingers from abrasions arising from contact with the ulcerated initial sclerosis, or the lymph or blood of infected patients. The site of vaccination is likewise occasionally the seat of a syphilitic chancre, and the infection has been conveyed in ritualistic circumcision, the source of the contagion here being mucous patches in the mouth of the operator, it being customary to place the infant's penis therein after the operation. Vaccino-syphilis can occur only when blood from a syphilitic subject is transmitted along with the vaccine virus.

The gummas of the skin and subcutaneous connective tissue resemble

closely at first glance the initial infiltration at the point of infection. The latter, however, will be found to occupy the tissue of the skin almost exclusively, while the former may or may not invade the deeper structures. The gummas of the skin generally appear as a late manifestation of the disease. They may disappear by absorption without ulceration, or they may break down into ulceration, and by fusion with several in the immediate neighborhood form a spreading and creeping ulceration (**serpiginous ulcer**). The gummas extending into the subcutaneous connective tissue or originating in it are liable to occur as large infiltrated areas, but undergo the same changes. Gummas of the skin and subcutaneous connective tissue affect particularly the forehead, neck, shoulders, and legs, named in the order of frequency of occurrence of the gummas.

The **treatment** of a sore suspected to be the initial sclerosis of syphilis should be purely local. Under no circumstances should the practitioner be induced to treat constitutionally what may not prove to be a genuine syphilitic infection on the chance of its being such. By so doing he robs the patient of the only means of knowing whether or not he really has syphilis, by preventing the occurrence of the secondary syphilitic skin lesions, which are decisively diagnostic and final. The prevention of the occurrence of these does no real good, inasmuch as no harm can arise from their presence. **Early excision** has been practised with the view of preventing the constitutional development of the disease, and some success has been claimed for this. In cases of supposed arrest of the disease by excision conclusive evidence that the disease ever existed is, of course, wanting. Then, too, the long delay in the appearance of the local lesion suggests that the primary sore is really only the local expression of a constitutional infection which has been undergoing a process of incubation in the interval. Such considerations have impaired the confidence of surgeons in primary excision of chancre for the prevention of syphilis. Therefore, in the treatment of chancre simple antiseptic dusting-powders, or some form of antiseptic dressing fulfil all the indications.

Gummas of the skin and subcutaneous connective tissues occur among late lesions of the disease, and are to be treated on general antisyphilitic principles. In case ulceration takes place, excision or curetment is indicated, generally the latter. This is to be followed by the application of zinc chlorid in a 10 per cent solution, with after-dressings of sublimate moist gauze.

Leprosy.—When **Bacillus leprae** invades the body, it manifests its presence in a variety of ways. Early in the disease, months, and it is said years, sometimes elapse before the appearance of local manifestations. In the meanwhile the patient suffers from general malaise, languor, chills, fever, and osteocopic pains. The most prominent of the local symptoms are the lesions of the skin. These may be bullae, maculae, or tubercles. Based on these different manifestations, varieties of the disease have been described, such as tubercular, macular, etc. As all these lesions may, and usually do, appear in the same patient, there seems to be no good reason for making such distinctions. As a matter of fact, the first cutaneous manifestation of the disease is the appearance of bullae. As the deeper cutaneous structures become involved, maculae develop, of a red color at first (the lepra rubra of some authors), this fading later into a brownish hue. With the appearance of the maculae, symptoms of peripheral nervous disturbances show themselves, first, as hyperesthesia

from irritation, and, second, as anesthesia from loss of function. As the disease advances, tubercles make their appearance on all parts of the body, most numerous, however, on the more exposed regions. These may or may not ulcerate, though they usually do. With the invasion of deeper structures, such as the subcutaneous cellular tissue, the muscles or bones, atrophy may take place, and, as the bones and joints are attacked, the fingers and toes drop off. Greater mutilations may occur, even to the loss of hands and feet. In the skin of the face a peculiar hypertrophy with wrinkling takes place, giving rise to the peculiar facial appearance called **leontiasis.** These different lesions do not make their appearance in any regular order. They may exist together. The tubercles may predominate, in which case we have the so-called tubercular leprosy; or maculae and general anesthesia may be the characteristic features, in which case we have the anesthetic leprosy of some writers. It is evident that the disease is the same in all cases, and that the varieties which have been described depend really on the structure attacked by the bacillus, which is in every case identical. This disease is not to be confounded with elephantiasis Arabum.

The **prognosis** of leprosy is exceedingly grave. It is essentially an incurable disease. The victim usually perishes of exhaustion, or of some secondary wound disease, such as tetanus.

There is a disease common to tropical climates called **elephantiasis Arabum,** or, from the frequency with which it is seen in the West Indies, **Barbadoes leg.** It is not to be confounded with elephantiasis Graecorum, or leprosy, to which it is in no respect akin. It may attack any part of the body, but in the great majority of cases the lower extremities are the seat of the disease; next in frequency the genitalia, more especially the scrotum in the male and the labia majora in the female, are attacked. The disease is characterized by great hypertrophy of the skin and subcutaneous tissue. The skin itself becomes fissured, roughened, and edematous, and hangs in enormous folds, giving to the limbs, when the disease occurs there, the appearance of elephant legs. The hypertrophy is very great, so that a scrotum the seat of the disease has been known to weigh a hundred pounds. It commences like an erysipelatous inflammation, but constantly recurs, each attack leaving more and more thickening of the tissues. It is supposed to be due to obstruction of the lymphatics of the part, though the etiology of the disease is still obscure. In very numerous cases **Filaria sanguinis hominis** has been discovered in the blood, and to this parasite have been attributed the origin of the obstruction and the inflammatory lymphangitis which is uniformly present. Operative procedure offers the only hope of relief from the disease. When it occurs in the penis and scrotum, early amputation is largely successful. When the disease has appeared in an extremity, ligation of the femoral artery has been practised, with much less success, however. The immediate result of the operation has been a prompt diminution of the size of the limb, but unfortunately improvement has been but temporary. In early cases ligation of the external iliac artery gives better results (Hueter). Digital compression has been tried with some benefit, but early amputation offers the best hope of permanent relief.

INJURIES AND DISEASES OF BLOOD-VESSELS

INJURIES OF ARTERIES

In severe crush injuries to the limbs the vessels are ruptured or torn across, and in machinery accidents they are frequently twisted. Under these circumstances the bleeding is comparatively slight. This is due to the fact that the internal and middle coats are more easily torn than the outer, and give way first, thus occluding the lumen of the vessel. The occlusion results from the rolling in of the middle coat or the retraction of it, and occurs in the fraction of a second. In case of a crush injury the adventitia or external coat is forced about the retracted ends of the middle coat; in case of a machinery accident, the member is usually forcibly twisted, and therefore torsion of the external coat still further supports the retracted ends of the internal and middle coats. Further, the elastic middle coat sends prolongations of its elastic fibers into the closely woven network of connective tissue which constitutes the external coat (Ballance and Edmunds), so that a retraction of the middle coat involves some retraction of the external coat as well. The middle coat will likewise vary according to the age of the individual, and differences will be noticed in different portions of the same body; consequently, the facility with which the retracted middle coat closes the lumen of the vessel will vary.

Contusion of the artery is sometimes occasioned by the striking and glancing off of a bullet or other missile. The artery, unless held firmly in position against a bony surface by overlying structures, will be pushed aside, though bruised by the contact. Under these circumstances the injury to tissue may be so great as to cause rupture of the vessel and so-called secondary hemorrhage (*vide infra*). The catastrophe from this cause may be expected in from eight to ten days after the injury. In other instances the supposed contusion turns out to be really a partial rupture of the artery, a portion of the intima giving way, this curling up and producing occlusion more or less permanent at this point. Gangrene of an extremity may occur as the result of complete or partial rupture or contusion. In case of partial rupture the thrombus which is formed is of irregular shape. This irregularity in shape leads to a further fibrinous deposit, and, as this occurs evenly and follows the shape of the original thrombus as a mold, it happens that the latter is continued almost indefinitely, in time occluding the entire trunk and its collateral branches. Thus the blood-supply of the part is cut off and more or less extensive gangrene results.

Gunshot Injuries of Blood-vessels.—The proportion of injuries of large vessels, or those requiring the application of a ligature, to the total number of wounds received in battle, exclusive of those which prove immediately fatal from hemorrhage, is astonishingly small. This is the more surprising in view of the fact that, in the case of the old-fashioned unprotected spheric leaden missile, the smashing of bone, the splitting of the projectile into fragments, and the deformation of the bullet greatly contributed to increase the chances of injury of neighboring blood-vessels. The liability to the wounding of blood-vessels in this manner is lessened in the case of the modern high-

velocity and mantled projectile, the smaller size likewise contributing to the escape of the vessels. On the other hand, however, the high velocity, pointed form, and direct course of the projectile through the tissues increase the chances of direct injury to the vessels in its path.

Death from external primary hemorrhage is very rare; the same may be said of the necessity for immediate ligation of a large vessel. Recurrent and secondary hemorrhages when caused by the modern projectiles are likewise uncommon, though they take place with sufficient frequency to keep the surgeon alert as to the possibilities of their occurrence. Such injuries as contusions or lacerations without the invasion of the lumen of the vessel may occur, to be subsequently followed by ulceration in the case of the former, and by complete perforation in the case of the latter. The secondary hemorrhage which results may occur in a few hours, or it may be postponed for from one to three weeks. It is most likely to occur in the presence of suppurative conditions; in fact, the latter are largely responsible at the present day for the occurrence of secondary hemorrhage. On the other hand, even if aseptic healing takes place, various kinds of aneurisms may occur as a part of the after-history.

Incised and punctured wounds of arteries have for their primary symptoms, except under the rare circumstances of a valvular opening in the overlying parts, active and visible hemorrhage in an interrupted or *per saltum* stream varying in size and force according to the vessel involved and the size of the external wound. The bright red color of the blood, as well as the jetting character of the stream, will serve to distinguish this from venous hemorrhage.

In punctured wounds, in which the wound of the overlying parts is such as to produce a valvelike closure of the external opening, escape of the effused blood is prevented, and this may collect around the injured artery. The pressure of the clot in case of small arteries causes spontaneous arrest of the hemorrhage, but in large arteries a **traumatic aneurism** develops (see page 96).

Lateral wounds of the arterial wall, as a rule, produce the most alarming hemorrhage. This is more particularly true when the wound is at right angles to the long axis of the vessel. Here the elastic middle coat, the fibers of which have principally a longitudinal direction, retracts, and very active hemorrhage results from the wide gap in the vessel which this retraction produces.

Complete transverse separation of an artery leads to a retraction of the ends thereof, on account of the marked elasticity of the middle coat, which produces a constant tension on the arterial tube, and a narrowing of the lumen, in addition, by the action of the constrictor muscular layer. The extent of the retraction will vary according to the size of the vessel and the thickness of its middle coat. The arrest of hemorrhage, under these circumstances, will be governed by these considerations, as well as by the character of the tissues within which the vessel retracts. If these are large masses of muscular tissue, the spontaneous arrest will take place earlier, while if they are mostly masses of loose connective tissue, spontaneous arrest will be delayed. The retraction within large masses of muscular tissue tends to impede free escape of the blood, and, therefore, after the blood has left the vessel, coagulation is favored. When the hemorrhage takes place into loose connective-tissue planes, the accumulation of blood here will cause lateral pressure on the

trunk of the divided vessel, and thus arrest will be brought about. Finally, the failing power of the heart's action, whether from shock or from acute anemia, favors coagulation and lessens or arrests the hemorrhage. In the latter condition death may follow unless closure of the wound in the artery and infusion of saline solution are promptly performed.

Spontaneous Arrest of Hemorrhage.—This, though it may appear to be complete, is not to be relied on as permanent. In the case of the large vessels, particularly in the course of a few hours, when the heart's action becomes more forcible, the obstructing coagula may be washed away by the increased flow of blood, and **recurrent hemorrhage** occur.

The occurrence of **secondary hemorrhage** depends on septic inflammatory complications in wounds. Arteries which have been torn or laterally contused are particularly liable to secondary hemorrhage. Divided and ligated arteries are likewise liable to septic invasion, and hence to the same complications, though not in the same degree, as the foregoing. The damage done to contused and lacerated vessels is much greater than that which occurs after simple application of a ligature; hence, the local vital resistance is not lowered to the same extent in the latter case as in the former. Should the wall of the vessel become so weakened as to be unable longer to resist the force of the arterial wave, it will give way under the pressure from within. Secondary hemorrhage occurs rarely before the fourth day and very seldom after the twelfth. Coincidentally with the appearance of the process of repair as announced by the presence of healthy granulations, the dangers from secondary hemorrhage disappear. As long as these granulations remain in a healthy condition, no further danger from this source is to be feared (see page 88).

Subcutaneous Injury of Smaller Vessels.—Contusions produce more or less tearing of the smaller vessels, both arteries and veins, in the subcutaneous connective tissue. As the blood escapes into the meshes of the latter, it coagulates and forms what is known as a **hematoma.** The more or less solid tumor thus formed will vary in size according to the extent of the extravasated blood. A familiar form of hematoma is that found on the head of a new-born child, in which, however, the blood usually remains fluid (cephalhematoma). A blow upon the head, causing rupture of the vessels of the scalp from impingement against the skull beneath, sometimes produces extensive hematoma. The center of this is often found to be quite soft, partly because the connective-tissue fibers at this point tear, and partly because the central mass of the blood remains fluid. This, surrounded by the more solid and elevated margins, may give the impression of a depressed fracture of the skull. When the hemorrhage occurs in otherwise healthy joints as the result of injury, it is known as **hemarthrosis.**

The swelling which follows a subcutaneous injury to the vessels slowly disappears, and coincidentally therewith there appears on the surface at first a blue or a bluish-red tint, followed later on by a greenish and a yellowish tint. The disappearance of the swelling is due to the resorption of the blood, and the discoloration is due to the coloring-matter of the latter, which is set free by the destruction of the red blood-corpuscles in the extravasated blood preceding resorption. As time goes on, the discolored skin resumes its normal appearance, the coloring-matter and serum being taken up by the lymph-channels.

In the great majority of cases resorption of the extravasated blood takes

place without leaving any trace of its presence. Occasionally, however, a connective-tissue proliferation surrounds the hematoma, and a cyst with serous contents is formed. In still rarer instances the so-called organization of the clot occurs, *i. e.*, the surrounding connective tissue in its proliferation invades the clot, and repair takes place in this manner. As a rule, however, resorption, and not cicatrization, constitutes the method of restoration.

All hematomas, however, do not follow this favorable course. Bacterial infection, occurring either through the tightly stretched and poorly nourished skin, or along the sheaths of the hair-follicles, or having its origin in the blood itself, may produce a purulent condition of the mass. The suppuration may then assume a phlegmonous character, spreading into the surrounding connective-tissue spaces and into the opened up lymph-channels, or may become localized and slowly point toward the adjacent surface, according to the more or less active infectious agency of the bacteria.

In the **treatment of hematoma** two indications are present: (1) the promotion of absorption ; (2) the prevention of suppuration. The first is fulfilled by massage, which breaks up the clot and stimulates the absorbents. Thorough cleansing of the injured part and the application of an antiseptic moist dressing (sublimate, Thiersch's, or a carbolic solution) will meet the second indication. If suppuration has already occurred, or the tension is considerable and massage too painful to be borne, free incision with antiseptic precautions must be made. The clot is to be turned out, the resulting cavity irrigated with sublimate solution, 1:2000, and subsequently packed with sterile gauze wet with hydrogen dioxid, the dressing being completed by a wet sublimate compress.

HEMORRHAGE

This term is applied to an escape of blood from the vessels. It is more generally applied to an escape of blood to the surface or into a cavity of the body. The latter is known as **concealed hemorrhage.** The term **extravasation** or subcutaneous hemorrhage is employed to designate an escape of blood into the subcutaneous connective tissue.

Hemorrhage may be divided into **primary, recurrent,** and **secondary.** The first immediately follows the reception of the wound. The second follows reaction from the shock or injury, and is due to the increased power of the circulation either displacing the coagula which have formed and which held the bleeding in check, or forcing the blood from wounds of the smaller vessels.

Secondary hemorrhage may be due to a contusion or abrasion of the wall of the vessel which at first passed unrecognized, the wall subsequently giving way. It may be due to an inefficiently applied ligature, or to a failure to apply a ligature to the distal end of a divided vessel, which on the establishment of the anastomotic circulation furnishes blood. Premature softening of an animal ligature may also give rise to secondary hemorrhage. **Disease of the walls of the artery** (page 93), **septic processes** (page 86), as well as certain constitutional conditions, such as **hematophilia, septicemia, pyemia, renal** and **hepatic disease,** may give rise to secondary hemorrhage by interfering with the plastic and proliferative changes necessary to the definite sealing of wounded vessels.

Symptoms of Hemorrhage.—When death is threatened from hemorrhage, the following symptoms, more or less pronounced, are present: (1) The external appearance of blood. This will vary according to the size of the injured vessel and the rapidity of the flow. It may be absent altogether, a sufficient quantity of blood escaping into one of the larger cavities to produce syncope (**concealed hemorrhage**). (2) A peculiar hue of the surface. This is a combination of pallor and lividity due to the fact that the flow of blood from the vessel, particularly an artery, lessens the *vis a tergo* in the peripheral vessels, and a venous stasis is added to the otherwise pallid surface. (3) Coldness and a clammy condition of the surface. (4) Dilatation of the pupils and twitching movements of the eyeballs. (5) Sighing respirations and diaphragmatic breathing. (6) General restlessness, and the throwing about of the extremities, particularly the arms. (7) Involuntary evacuation of urine and feces. (8) Rapid and weak pulse. (9) Coma; more rarely convulsions.

In addition to these, the patient complains of giddiness, oppression of breathing with occasional gasping efforts (air hunger), intense thirst, and disturbances of vision and hearing.

Death may occur rapidly, or the lowering of the circulatory tension may give an opportunity for the formation of coagula at the point of injury; the bleeding may then cease. The patient rallies, but the increasing power of the heart's action forces away the clot from the interior of the injured vessel, and the patient relapses into his former condition. This may be repeated several times until fatal anemia of the important nerve-centers occurs.

The rapidity with which the symptoms of hemorrhage supervene varies in different individuals, and at different periods of life. A very small loss of blood may produce fatal syncope in weak or nervous individuals; on the other hand, robust or phlegmatic persons may suffer a considerable loss without showing pronounced symptoms. The more rapid the loss, the greater the danger. Women bear the loss of blood better than men. Children and aged people, as well as stout persons, do not bear the loss of blood at all well. Arterial hemorrhage produces greater depression than venous.

If death does not occur, there is a reactionary stage. The occurrence of fever has been noted (**hemorrhagic fever**), but it is difficult to separate this from febrile disturbances due to septic changes. Convalescence is slow, and a condition of chronic anemia may last for a long time.

(For treatment of hemorrhage, see Operations on Blood-vessels, page 336.)

LIGATION OF ARTERIES

The most simple and trustworthy method of closing an incised or punctured wound of an artery is by ligation. After ligation of an artery in continuity certain **changes take place in the neighboring circulatory apparatus.** At the moment when the flow of blood in the tube is obstructed the current at once sets in the direction of the lateral branches which are given off nearest the seat of ligation, with an increased pressure. These lateral branches, in their turn, communicate with arteries given off from the arterial trunk beyond the place at which the ligature is applied, and thus the blood finally reaches its original destination, albeit by a more or less roundabout course. The completed circulation thus established is known as the **collateral cir-**

culation (Fig. 19). This anastomotic or collateral circulation is usually restored at once in every ligated artery, and makes for itself, according to the number of the collateral branches and the amount of the blood-pressure, more or less wide channels for carrying on the circulation. The combined area of the collateral branches equals that of the trunk which has been ligated, and the blood-supply normal to the part is finally furnished. The exception to the rule is found in cases in which diseased conditions of the arteries or infiltration of the surrounding tissues prevents a prompt enlargement of the anastomosing branches, and thus the blood-supply to the periphery is retarded or entirely prevented. Under these circumstances gangrene is the inevitable result.

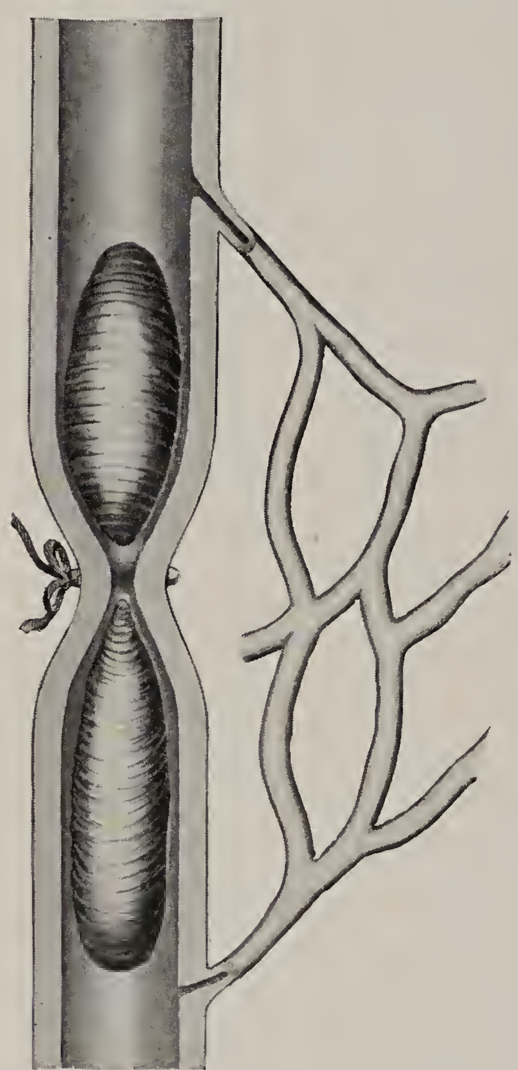

Fig. 19.—Schematic Representation of an Artery Ligated in Continuity.
Showing the established collateral circulation and the formation of the clot (after Hueter).

The Changes Which Occur in the Vessel.—When an artery with healthy walls is tightly constricted by a ligature secured by a knot, the two inner coats or tunics proper, the intima and media, give way and are separated by the pressure of the thread. The adventitia or external coat, however, remains intact, but is constricted in a narrow circle. The intima and media, mainly from their elasticity, retract or curl upon themselves as their division takes place, and, the longitudinal elastic tension on the arterial tube being relieved by the division of the elastic middle coat, on which it depends, a separation of the divided ends occurs to a greater or lesser extent. The vessel just beyond the limit of the clot is constricted somewhat, this constriction varying with the particular artery involved.

The application of a ligature in such a manner as simply to **occlude,** but not rupture any of the coats of an artery, two or more ligatures being placed side by side and tied by a so-called "stay-knot" (see Fig. 128) for this purpose, has been proposed as a substitute for the ordinary method of ligation in which rupture of the two inner coats takes place (Ballance and Edmunds).

Changes Which the Blood Undergoes.—It was formerly supposed that the mere arrest of the blood at the point of ligation was sufficient to permit its coagulation, this arrest giving opportunity for the fibrinoplastin, or paraglobulin (Schmidt), and the fibrinogen to act on each other. Later researches, however, have shown that a third body of the nature of a ferment is needed. This has been shown to have its origin in the so-called "blood-plaques," the death and disintegration of which give rise to the ferment. The coats of the artery being ruptured, fibrin is first deposited on the damaged recurved tunics; the disintegration of the cell containing the **fibrin ferment** is thereby initiated. When the coats are uninjured, as may happen, either intentionally or otherwise, it has been asserted that clotting does not take place, particularly on the side above the ligature, nor where a collateral

branch of sufficient size exists (Dent and Delépine, Paul Bruns). It has been maintained that the two opposing surfaces may be made to cohere by multiplication of the endothelial cells, without the formation of a clot (Riedel). On the other hand, experiments made with reference to this point show that clotting always takes place, whether the tunics are ruptured or not, Furthermore, the presence of collateral branches of not inconsiderable size in the immediate neighborhood does not interfere with the formation of a clot, the latter not infrequently passing into these (Ballance and Edmunds). The view that coagulation always takes place when the normal conditions of the vessel are interfered with sufficiently to prevent the blood-current from continuing its course through the same, even when the tunics are not ruptured, is probably the correct one (Michael Foster). Under these circumstances a profound alteration in nutrition is established, the vasa vasorum become blocked, and a plastic effusion ensues as a result of the presence of the ligature, which acts as a foreign body. The effusion buries the loop of the ligature, this taking place sometimes as early as thirty hours after the operation. Simultaneously the opposed endothelial surfaces proliferate and adhesions form between them (Ballance and Edmunds). The formation of the coagulum does not take place so rapidly with unruptured coats as with ruptured ones. This is due to the fact that the fibrin is not deposited until the occurrence of the blocking of the vasa vasorum, the exudation of plasma, and the migration of the leukocytes. The coagulation, under conditions favoring its occurrence, may be initiated in an hour. It is not likely to be delayed beyond six hours.

In small vessels the coagulation takes place up to the nearest collateral branch. In the large vessels this varies. The proximal clot is generally the larger. Immediately above the ligature an apparent ampulla is formed (Bryant). This enlargement in reality depends on a contraction of the vessel above the clot (Warren). The clot does not distend the vessel; it fits the tube but loosely, and a space is frequently found between the clot and the surface of the tunica intima, though the clot is attached to the latter here and there.

The Function of the Clot.—The clot takes no part in the process by means of which the obliteration of the vessel is produced. Its function seems to be threefold: (1) it acts as a cushion against which the impulse of the blood is received, and in this manner prevents any disturbance of the plastic processes which are in progress at the seat of the ligature; (2) it forms in this situation, as in other localities where processes of repair are going on, a trellis-work support to cell invasion, as the latter proliferates from side to side of the interior of the arterial tube; (3) it serves as nutriment for these cells.

The Fate of the Ligature.—A ligature applied to a blood-vessel is always treated by the tissues as a foreign body and an attempt made at once on the part of the cells to absorb it. The material of which the ligature is composed will determine the success of this attempt. In the case of gold or platinum wire, this remains permanently in an unchanged condition. Ligatures of silver, lead, iron, and other metals become absorbed sooner or later. All animal and vegetable ligatures disappear in time, this varying with the character of the ligature material and the method of its preparation.

If no bacterial infection follows the operation the wound will unite by first intention, a mass of plasma-cells rapidly surrounding the ligature. This collection of cells will be greater on the tissue than on the vessel side of the ligature. The plasma-cells, in attacking the ligature, provided it is of a material which will permit its absorption, such as catgut, kangaroo tendon, reindeer tendon, silk or Chinese twist, etc., penetrate into its interior as well, and its more or less rapid absorption follows. If there is any delay in the absorption, encapsulation occurs from the formation of connective tissue; the absorption is not on this account arrested, but goes on, although slowly, to completion. As absorption takes place, the ligature material is replaced by new connective tissue. In the case of animal ligatures the softening and absorption of the ligature occur earlier if suppuration takes place. Under these circumstances catgut, unless chromicized or otherwise hardened, may completely disappear in fourteen days. Good chromic gut, however, in a septic wound, may be relied upon to hold sufficiently long for all purposes of ligation; ordinary gut, prepared by boiling in alcohol, will, in general operative work of an aseptic nature, be found to be entirely trustworthy. But in ligation in continuity of large arteries near the heart, in which case special precaution is necessary, well-chromicized catgut will be the safest to employ.

The reparative process by means of which the final obliteration takes place does not differ materially, after the formation of the clot, from that which occurs elsewhere. The proliferation of the cellular elements of the intima leads to connective-tissue formation, the clot is invaded by the cell growth, and a regenerative or hyperplastic inflammatory condition occurs, somewhat resembling that which marks the formation of callus after fracture of a bone (see page 130).

If the ligature does not occlude the artery at the time of the operation, or if it is of such material or the conduct of the wound is such as to lead to the too rapid softening of the ligature, or if the knot gives way too early, the **circulation through the vessel may become reestablished.** This may occur in cases in which the internal coat of the artery is not ruptured, and also where the external coat or adventitia is completely divided. Again, it may happen that a diaphragm forms between the ligated ends of the vessel, through which a central opening passes.

Reestablishment of the circulation after a clot has formed may take place in one of three ways: (1) The central mass is divided by cell invasion in such a manner as to form spaces, which are bounded toward the center of the clot by endothelial cells, and externally by the intima of the vessel, these constituting true blood-channels. If the force of the blood-current is sufficient, these may be so enlarged that they will be converted into one, the young and slender connections between the lining of the vessel and the central clot giving way. In this way a peripheral reopening of the vessel lumen may take place. (2) The vessel may become pervious by an opening forming through the center of the clot. If the development of connective tissue does not proceed in such a manner as to protect the cells or granular material of which the portions of the clot between the spaces are made up, these may be washed away and the former transformed into lacunae filled with moving blood, so that the circulation is accomplished through a kind of **cribriform or sieve-like membrane,**

which takes the place of the original clot. (3) The connective-tissue development taking place more rapidly in the periphery than in the center of the clot, the latter of which is the natural course, true **canalization of the clot may occur.**

DISEASES OF ARTERIES

Arteritis.—The influence of surrounding conditions of infection of arteries, or so-called perivascular suppuration, is such as to induce suppurative inflammation of the vessels of the arteries. The vessels of the connective tissue covering the artery, or the adventitia, are chiefly affected. The interference with the nutrition of the artery is such as to lead to coagulation in the latter, particularly in the smaller arteries **(intra-arterial thrombosis).** Injury of the wall of the vessel, the resulting coagulation undergoing suppuration, is followed by **thrombo-arteritis.** Larger arteries do not suffer so readily from attacks of suppurative inflammation; they have been observed to resist for a long time the influence of surrounding septic conditions.

Chronic arteritis is more frequently observed than the acute form. The chronic form of the disease (1) may result from previously existing degenerative processes, or may accompany the latter; (2) may precede these degenerations and be the initial factor in their production. The degenerative processes which invade the artery, and which may be accompanied or followed by a chronic arteritis, are fatty degeneration and calcification of the intima, and amyloid degeneration of the intima and media.

The chronic inflammation of the artery known as **endarteritis deformans** is the most common form of the disease. It usually occurs in persons beyond middle life; it is very rarely observed in those under fifty. It begins in the shape of small yellowish spots on the intima, and is suggestive of a fatty granular degeneration of the subendothelial layer. These spots coalesce and form plaques, which finally undergo calcification. This is the course usually followed, but somewhat rarely the fatty softening proceeds to the formation of excavations filled with detritus, this, on account of a fancied resemblance to retention cysts of sebaceous glands (the so-called atheromas), constituting the condition known as **atheromatous degeneration.** In chronic endarteritis the rigidity of the walls of the vessel is not due to an atheromatous condition, but rather to irregular condensation and thickening. The elastic subendothelial layer is connected with a more or less solid membrane in cases of calcification; the loss of elasticity due to this leads to dilatation of the arterial tube, with lengthening, and the production, sometimes, of a serpentine course of the artery. This can be often observed in the superficial arteries of old people, particularly in the temporal and radial arteries, occurring coincidentally with other senile changes and perceptible both by touch and by sight. The disease is not confined to these vessels, however, but occurs throughout the entire arterial system, including the coronary arteries and the surface of the mitral valve.

There are two forms of surgical disease which follow chronic endarteritis or are in close association with it. These are **senile gangrene** and **aneurism.** The first-named affection will be discussed more fully among the diseases of the lower extremities, for the reason that it makes its first appearance, as a rule, in that locality. It may be said, however, that calcification of the arteries is in most instances the cause of senile gangrene; it may be so considerable

as completely to obliterate the lumen of the vessel, and thus the supply of blood is shut off from its area of distribution. Obstruction of smaller branches of the main trunk may result from the loosening of the calcified patches, which are carried as emboli by the blood-current until they reach the smaller arteries, where they lodge and obstruct the circulation. The occurrence of embolism is characterized by severe pains in the regions of the nerves supplied by the vessel involved. If the collateral circulation is insufficient, stasis occurs in the capillaries, the local temperature is lowered, and gangrene follows (**embolic gangrene**).

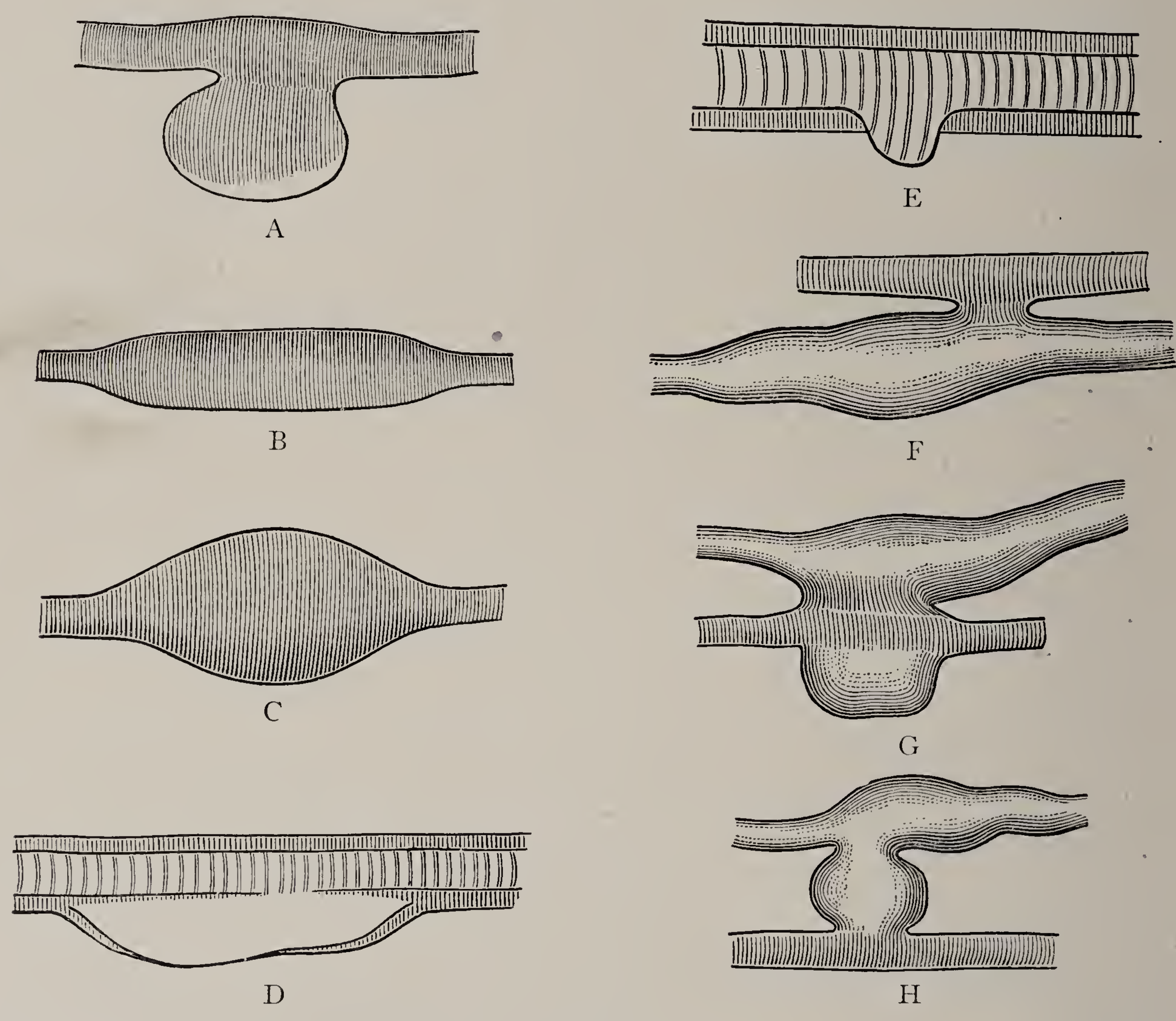

Fig. 20.—Schematic Representation of the Different Forms of Aneurism (after Manteuffel). A, Sacciform aneurism; B, cylindriform aneurism; C, fusiform aneurism; D, dissecting aneurism; E, the mechanism of the production of the diffuse form of sacciform aneurism through rupture of the elastic elements of the arterial coats; F, arteriovenous aneurism, showing a direct communication between the artery and the vein, with dilatation of the vein alone; G, arteriovenous aneurism, with dilatation of both artery and vein; H, arteriovenous aneurism with the formation of a sac between the artery and the vein.

Aneurism.—Aneurism is a dilatation of the lumen of an artery filled with circulating blood. This definition includes dilatation limited to a portion of the artery, as well as the condition in which an enlargement of the entire arterial system of a part occurs (**cirsoid aneurism**).

Aneurisms are **classified** on the basis of an invariable involvement, or otherwise, of all the coats of the vessel in the disease. The first-named condition is known as true aneurism, while the second is called false aneurism.

True aneurisms are divided, according to their shape, into (1) **sacciform;**

(2) **cylindriform**; (3) **fusiform** (Fig. 20). These forms are nontraumatic in origin, and are marked by a gradual dilatation of the vessel; the dilatation takes one or more of these shapes according as the entire circumference of the vessel, or only a portion thereof, is involved.

False aneurisms, or those in which all the coats of the vessels do not take part in the enlargement, are usually the result of an injury involving partial division or destruction of the arterial wall. The mycotic form may also occur as a false aneurism.

Occurrence of Aneurisms.—True aneurism occurs most frequently in the decade between thirty and forty years of age, when structural changes in the arterial coats, due to syphilis, rheumatism, gout, and excesses in diet, are most common. It is very rare before puberty, and the frequency of its occurrence gradually decreases after the age of forty, when the heart's action gradually becomes weakened. Less than 19 per cent occurs in women (Lüttich). It is more common in cold than in hot countries. It occurs most commonly in the following vessels, mentioned in the order of frequency of occurrence of the aneurism: The ascending and transverse portions of the thoracic aorta; the popliteal, carotid, subclavian, innominate, and axillary arteries. Cirsoid aneurism occurs especially on the scalp, and is usually congenital. Rarely, it occurs from some mechanic injury.

Etiology.—Etiologically all aneurisms are either **dilatation aneurisms** or **rupture aneurisms.** All diseased conditions or injuries of the arteries by which the strength and elasticity of their walls are diminished, may give rise to either one or the other of these forms. These include the following: (1) chronic endarteritis; (2) periarteritis with secondary atrophy of the media; (3) contusions, wounds, and subcutaneous ruptures of arteries and their sequels (cicatricial weakening of the vessel wall); (4) degeneration of the vessel wall through infectious diseases (typhus, etc.).

Sometimes a combination of circumstances operates to produce the aneurism, such, for instance, as the presence of primary ruptures of the media due to a diseased condition or traumatism, and a marked elevation of blood-pressure from some strong physical exertion or violent emotion, whereby the resistance of the arterial wall is overcome. Syphilis is a frequent cause of aneurism of the aorta.

Aneurism arising from **endarteritis** may partake of either the sacciform, the cylindriform, or the fusiform shape. In the first two the entire circumference of the vessel may be involved, while in the latter only a portion of this forms the aneurism. Where the diseased portion of the vessel, although occupying the entire circumference, is sharply limited in a longitudinal direction the aneurism will be **cylindriform** (Fig. 20, B); where the limits of the diseased portion are not so sharply defined, but merge gradually into the adjoining and less diseased portion, the aneurism will be **fusiform** (Fig. 20, C). Where dilatation takes place at a single point and but a portion of the circumference of the vessel is involved (Eppinger), the aneurism will be **sacciform** (Fig. 20, A). In the more or less diffused forms the elastic elements of the arterial coats give way at numerous points in the same locality (Recklinghausen) (Fig. 20, E). Endarteritis being a more or less widely diffused disease of the vessels, dilatation may occur at several points in the same vessel, or may be present in several vessels at the same time.

Locality has some influence in the development of aneurisms. They have a special predilection for those portions of arteries where divisions of main trunks occur, as, for instance, the point of division of the innominate, of the common carotid, of the femoral where the profunda is given off, and of the popliteal where it divides into the anterior and posterior tibial. This seems to arise from the fact that a slight fusiform dilatation occurs at these points normally, and under pathologic conditions further enlargement occurs the more easily. Aneurism is also more likely to occur where the artery is embedded in soft tissues with absence of firm external support. It likewise tends to arise where the vessels are exposed to injury at the points of flexion of the extremities.

False Aneurism.—This includes all forms in which one or another, or all three of the coats of the vessel are missing from the wall of the aneurism. Traumatic aneurism is the most common variety of false aneurism.

Traumatic Aneurism.—This may arise from simple contusion of the vessel through consequent perforation by necrobiosis, though Mackow's experiments tend to show that contusions undergo repair at first. Subsequent yielding of the cicatrix may give rise to aneurism. It is usually due, however, to partial division of the vessel. Complete division of an artery does not develop into aneurism except in the rare instances in which it arises from the presence of a diseased vessel lying in a dead space and being without adequate support, in an amputation stump, or from improper ligation or the premature giving way of a properly applied ligature, and the subsequent canalization of a hematoma. The aneurisms arising from a punctured injury result from a gradual yielding of the thrombus which forms, and of the surrounding connective tissue, from intra-arterial pressure. Under these circumstances the sac which develops is made up, first, of the outer layer of the thrombus, and finally of the newly formed connective tissue, supported by the surrounding soft parts. In **subcutaneous rupture** of a large artery there is more or less separation of the coats of the vessel in a transverse direction, and extensive extravasation of blood in the perivascular connective tissue of the sheath of the vessel, which finally forms the wall of the sac of the aneurism. In **dissecting aneurism** rupture of the intima and media takes place, with preservation of the adventitia. The blood dissects its way between the media and the adventitia, separating these from each other. In **hernial aneurism** the defect is in the adventitia, and the inner and middle coats are forced through the opening.

Arteriovenous Aneurism (Fig. 20, F, G, and H).—This results from the simultaneous lateral injury of an artery and a neighboring vein, in which either a sac is formed in the connective-tissue sheath common to both, or direct agglutination of the artery and vein takes place at the point of injury. The wound of the artery and that of the vein, if directly in apposition, result in the formation of an arteriovenous aneurism or **aneurism by anastomosis** (Hunter) (**aneurismal varix, varicose aneurism**). This originates in stab or shot wounds, and abrasions by exostosis. In former times phlebotomy was a frequent cause. It has been observed in amputated stumps. In arteriovenous aneurism the arterial blood invades the vein and produces pulsation in the latter, with marked disturbance of the circulation, and pulsating dilatations of the branches of both artery and vein.

Pathologic Anatomy.—True aneurism contains within its walls all the constituents of the normal arterial wall, only altered and attenuated. Strata of shell-like thrombi line the inner wall concentrically in large sacciform aneurisms. Dissecting aneurism shows a defect in the intima; in hernial aneurism the defect is in the adventitia and muscularis. False aneurism arises in the beginning from the fluid center of a hematoma; later the sac develops from the connective tissue.

The Symptoms of Aneurism.—The presence of a pulsating tumor is the most important symptom of aneurism. The tumor will vary in size from a millet-seed to an adult head. The pulsation can be distinguished by the eye; each systolic act of the heart causes the tumor to pulsate, relaxing at the diastole. **A thrill or soft friction sensation** is conveyed to the examining finger by the passage of the blood over the rough walls of the sac. This latter symptom is heard, by the aid of the stethoscope, as a rough sound. Symptoms arising from **pressure on surrounding parts** are the following: (1) pain from involvement of nerve-trunks and filaments; (2) obstruction to the return circulation, resulting, in the case of the extremities, in permanent edema and new connective-tissue growth, simulating elephantiasis; (3) erosion and destruction of neighboring bony and cartilaginous parts.

Diagnosis.—When a pulsating tumor is present the following points must be borne in mind: (1) **The pulsation is expansile,** *i. e.*, it is felt to take place in all directions. In this manner an abscess which may rise and fall from proximity to a large vessel may be differentiated from an aneurism. (2) **Compression of the artery between the tumor and the heart** causes lessening or disappearance of the tumor, and arrests its pulsation and the thrill or friction sound. (3) In aneurism **the pulsating wave in the peripheral portion of the artery is retarded** as compared with that of the corresponding healthy vessel. In the **sphygmographic tracing** the curve is flattened and the point disappears. (4) The presence of a considerable amount of fibrinous coagulum within the sac may mask the pulsation. (5) Pulsation may occur in localities where contact with large vessels does not exist, as, for instance, the pulsation of the brain may become visible in case of a bony defect in the skull; the exposed medullary tissue of the long bones in some instances is seen to pulsate; thyroid or other highly vascular tumors, and certain varieties of osteosarcoma, likewise present this symptom.

The Terminations of Aneurism.—The **spontaneous cure** of traumatic aneurism occurs not infrequently. Stratiform deposits of solid masses of fibrin on the internal wall of the sac occur, the excavated portion, as well as the lumen of the vessel, becomes filled, and fibrinous contraction of the mass finally produces complete obliteration. Cure by nature's efforts, however, in aneurism depending on endarteritis is not to be expected. In the most favorable cases the dilatation may remain stationary. Between the progressive character of the endarteritis on the one hand, and the continued pressure of the blood-current on the other, steady increase of the dilatation is the rule. Structures other than the arterial walls may become involved in the disease. Large aneurismal dilatations of the aorta give rise to erosions of bony structures; even the vertebral column is invaded, its medullary cavity opened, and the spinal cord exposed. Anteriorly the bony chest wall disappears over a considerable area and the pulsating mass is visible externally. Nerve-trunks,

subjected to pressure, are disturbed in their function; violent pain or paralysis results. The aneurism may open externally, the overstretched skin ulcerating rapidly; **fatal hemorrhage** usually follows. Finally, a patient with aneurism is subjected to the dangers of embolism.

Treatment of Aneurism.—The indications for treatment include the following: (1) The treatment of the arteriosclerosis, on which true aneurism depends, by the **use of iodid of potassium,** whereby it is hoped to arrest the progress of the disease. (2) **The lowering of the blood-pressure,** both the volume and the force of the blood-current that enters the sac being thereby lessened, and **rest in the recumbent position** and **fasting** (Valsalva). The subjective symptoms of pressure and obstruction are relieved by these means. (3) Attempts to **cause coagulation of the blood entering the sac.** (For the operative treatment of aneurism see Operations on the Blood-vessels.)

INJURIES AND DISEASES OF VEINS

Incised and punctured wounds behave in a manner similar to that of arteries under the same circumstances. The walls of veins contain less elastic and contractile tissue, and consequently there is not the same amount of retraction of the vessel and contraction of its lumen as in the case of arteries. There is not, therefore, the same tendency to spontaneous arrest of hemorrhage in the case of an injured vein as in the case of an artery. This is somewhat compensated for by the fact that there is not the same amount of intravascular pressure in the veins as in the arteries, and blood is not so rapidly lost from this source. In operation wounds, the arteries supplying the parts being closed by ligation, the hemorrhage from the veins becomes less troublesome, from the fact that the supply of blood is cut off. It is fortunate that this is true, for the reason that the efferent branches of the large veins have very extensive and firm connections to the surrounding structures, in order to meet fully the demands made by constantly changing intra-arterial blood-pressure. These connections, each one of which is a small vein, if supplied with blood with the same force of current as that which exists in the arteries would increase very greatly the difficulty of arresting venous hemorrhage. Although **venous hemorrhage** is not so serious an accident as arterial, yet, under certain circumstances, a large amount of blood may be lost in a short time. Position, for instance, has a very decided tendency to increase hemorrhage from a vein. Without depending on the arterial blood-pressure, hemorrhage from a subcutaneous vein with the body in the upright position, particularly if this vein is in a **varicose condition,** will give rise to serious bleeding. The blood here escapes from the central end of the injured vein by the mere weight of the column of blood, in spite of the valvular apparatus of the veins which is intended to prevent reflux of blood.

Aspiration of Air into Veins.—A special danger in connection with wounds in veins at the root of the neck and in the neighborhood of the superior opening of the chest cavity relates to the **intravenous aspiration of air.** Each expiratory effort retards the return of the blood from the head and upper extremity to the large venous trunk within the thorax, and tends to force it back toward the periphery. An injury to either of the jugulars, the subclavian, axillary, or subscapular veins, or the cere-

bral sinuses, results in a crowding out of the large mass of dark blood from the wound. As an inspiration takes place the thorax is expanded, and the vacuum thus produced is filled by the blood rushing into the intrathoracic vessels. Whatever fluid other than blood is brought within the range of influence of this suction will likewise pass in. The escape of blood from the wound in the vein is held temporarily in check by the inspiratory effort; at the same time, however, more or less air passes into the vein, producing, in its passage, a peculiar hissing sound which, once heard, is never forgotten by the surgeon. Small quantities of air thus aspirated may do no harm, but a large quantity may cause immediate death. The exact mechanism by which this effect is produced is still a matter of dispute. The air passes from the right ventricle into the pulmonary circulation in aeriform emboli, the result of a "churning" process which the mixed air and blood undergo in that cavity by the contraction of the heart muscles. The emboli fill the branches of the pulmonary artery, and, these being obstructed, stasis occurs, the left heart collapses from want of blood on which to contract, and fatal syncope results from failure of blood to reach the cerebrum, while at the same time the right heart is paralyzed from inability to contract on the mingled mass of blood and air within its cavities. Although experiments on animals have repeatedly shown that quite large quantities of air can be injected into the veins without producing a fatal result, yet the fact remains that many patients have died from this accident, particularly during operations about the neck.

The diagnosis between venous and arterial hemorrhage is, as a rule, easily made. The former flows in a rather continuous stream, while the latter is forcibly ejected in interrupted jets. The blue color of the venous blood and the red color of the arterial blood constitute a striking difference. Exceptionally, however, this differentiation is embarrassed by the fact that the dark color of venous blood becomes changed to a lighter hue by contact with the air; the presence of arterial blood flowing from divided arterioles in the skin in cases of punctured wound of a vein may likewise mask the real source of the more serious bleeding.

Artificial arrest of hemorrhage from a vein is more rarely demanded than in the case of arteries of the same size. The reasons for this have been already mentioned. Circumstances frequently arise, however, which demand prompt action, both on account of the quantity of blood lost and on account of the danger of aspiration of air. Prior to the introduction of antiseptic and aseptic operative technic surgeons aimed to avoid, as far as possible, the placing of ligatures on veins. Infection and suppuration of the resulting intravenous thrombus occurred frequently, and here, as in the case of decomposition of an intra-arterial thrombus, secondary hemorrhage was liable to follow. The detachment of portions of this septic clot, its passage into the circulation, and its transportation in the shape of emboli, occurred from veins as well as from arteries. On this account ligation of the veins was resorted to only in the most urgent cases. The introduction of the **aseptic ligature,** however, has changed all this, and at the present day the application of the ligature is practised on veins and arteries alike. The frequently recommended and as frequently rejected **lateral ligation** of veins has at last been placed on a firm scientific footing by the introduction of antiseptic procedures. That the closure of veins without the formation of a clot may occur has been proved.

Varix.—The condition known as varix consists of a dilatation of the lumen of a vein, and corresponds to dilatation of an artery, or aneurism. A fundamental difference exists, however, in the method of origin of the two conditions. While the latter occurs either as the result of injuries to the arterial wall or from the presence of endarteritis, the former is the result of passive dilatation of the unchanged walls of the vein, which suffer by the accumulation of venous blood. The obstruction may be due to various causes, as follows: (1) occupations involving continuous walking or standing, the weight of the column of blood producing pressure on the lower extremities; (2) the pressure of the pregnant uterus and of large intra-abdominal tumors on the ascending vena cava; (3) physiologic conditions relating particularly to the distance of the parts from the heart, to which may be added abnormal conditions of these parts, as in fractures of the lower extremities followed by the formation of large masses of callus, the presence of bone tumors, etc. It may also be due to cardiac weakness and conditions involving obstruction to the entrance of venous blood into the heart. Pathologic changes in the connective tissue surrounding the veins, the latter losing their support from without, also favor the origin of varix.

Occurrence of Varix.—Varices occur more frequently in the lower extremities than elsewhere. For the purpose of surgical study we may group all cases subject to this hemadynamic condition within the area of the lower half of the body, where the return flow of blood in the veins is rendered difficult. This will include the veins of the spermatic cord, the pampiniform plexus, the veins of the lower part of the rectum (hemorrhoidal), and those of the lower extremity.

Varicose veins, as varices are sometimes called, undergo lengthening somewhat similar to that which occurs in arteries, in cases of endarteritis, and in aneurism. In the case of varix, however, this occurs to a much greater extent, the veins pursuing a tortuous course with numerous convolutions. Under the influence of constant pressure on the walls of the veins, in which elastic fibers exist to a much less extent than in arteries, these become thinned, together with the overlying skin, in the case of subcutaneous veins. These conditions are specially prevalent in the vessels of the thigh and leg. Below the ankle, as a rule, only a fine network of blue lines is seen. The veins of the gastrocnemius muscle are occasionally affected. Those which accompany the arterial trunks are comparatively exempt. The same may be said of the saphenous vein, the dilated veins occurring in the course of this trunk being really varices of the branches which join the saphenous near its upper limit.

Diagnosis.—Pressure applied directly on the dark blue, cordlike elevations and convolutions will cause a disappearance of the varices, while pressure, centrally applied, will cause them to increase in size.

Prognosis.—This, as far as danger to life is concerned, is favorable. Complications may arise, however, from the presence of varicose veins which may become sources of great inconvenience, and sometimes of real danger. Interference with the function of parts, particularly of the skin, leads to the production of inflammatory and suppurative processes. Eczema occurs in the legs, particularly of elderly persons. Ulceration of the skin follows comparatively slight abrasions; contusions give rise to sloughy conditions. Repair goes on very slowly under these circumstances.

Complications of Varix.—Thrombosis sometimes occurs as a result of retarded circulation in varix, this in time leading to obliteration of the latter by a transformation of the clot into solid connective tissue. This change is probably due, to some extent, to chronic inflammatory conditions in the neighboring tissues. The hard mass thus formed is solidly attached to the walls of the vein, and to the touch simulates a small fibroma. This occasionally becomes the seat of deposits of lime salts, constituting the so-called phlebolith, numbers of which may exist for years without serious inconvenience to the patient.

Rupture of a varicose vein may occasionally threaten life from profuse hemorrhage. Patients with varicose veins should be taught provisional methods of arresting hemorrhage. Septic changes in thrombi, followed by transportation of infectious emboli to distant parts, may occur. Septic metastases in the lungs and other parts (**pyemia**) constitute another dangerous complication. The latter termination is fortunately rare, however, for the reason that the inflammation is usually limited to the perivascular spaces.

Treatment.—This may be divided in a general way into palliative and curative. The former consists in supporting the parts surrounding the varices by properly applied bandages or their substitutes. **Compression** is secured by means of rubber bandages (Martin), bandages of "stockinet" material, and stockings made of silk with elastic threads interwoven. Operative measures will vary according to the location of the varices. These consist of ligation, with or without excision, as in varicocele, and in some cases of superficial varices of the lower extremities. In the latter cases, however, recurrences are rather common. **Injection of solutions of ergotin** into the perivascular connective tissue has been followed by good results (Vogt). Carbolic acid, sufficient to make a 2 per cent solution with the ergotin solution, should be added. Strict aseptic precautions should be observed, and the point of puncture made by the hypodermic needle protected by a drop of iodoform collodion.

Ligation of the internal or long saphenous vein at the saphenous opening, in properly selected cases, constitutes one of the best operative procedures for varicose veins of the lower extremity (Trendelenburg). The ligature should be applied below the point where the superficial circumflex iliac and superficial epigastric veins join the saphenous (see page 351).

Phlebitis.—Unlike the corresponding condition occurring in arteries, acute suppurative inflammation of the veins, or phlebitis, either alone or complicating subcutaneous and subfascial phlegmonous inflammation, or as a result of these, is not uncommon. Phlebitis pure and uncomplicated occurs most frequently in the leg and thigh. When it occurs in the course of the subcutaneous veins in the latter situation, the hard cordlike lines are quite easily distinguished. This cordlike hardness arises less frequently from coagulation of the column of blood in the inflamed veins than from more or less dense cellular infiltration of the adventitia and perivascular connective tissue. Coagulation, however, does occur in phlebitis, and is the result of a deposit of fibrin on the diseased intima.

Thrombophlebitis is that condition in which a suppurative inflammation situated peripherally to the subsequently inflamed vein causes a thrombosis in the latter, the phlebitis resulting. Here a minute thrombus forms in a capillary, and, charged with cocci, it is carried into the wall of the vein and

becomes attached to it, where it forms the nucleus for further deposits of fibrin. These in their turn become the seat of renewed suppuration and infect the wall of the vein. This thrombus may develop, by further deposit, to an extent sufficient to produce complete obliteration of the vein; it may likewise extend into the next larger vein (Fig. 21) or still further. During its existence the patient is exposed to all the dangers of pyemic invasion of remote parts.

While the thrombi just described have their origin in septic inflammatory conditions, either from the bacteria producing the coagulation or from their influence on the leukocytes in setting free the fibrin ferments (see page 90), thrombi likewise occur, exclusive of these influences, in otherwise healthy veins. These coagulations occur as the so-called **stagnation thrombi.** This thrombosis may happen from any obstruction, as, for instance, a ligature applied so as to obliterate the lumen of the vein. The vein from the point of ligature to the next collateral branch is filled with blood (the valvular apparatus being insufficient to prevent this), which remains for a time in a liquid state. Finally coagulation takes place, beginning at the wall of the vein, and the resulting thrombus obliterates the lumen. The continued presence of the carbon dioxid, in all probability, is the disturbing agent of the leukocytes; the disturbances which follow result in the setting free of the fibrin ferment necessary to the production of coagulation. The production of stagnation thrombosis is not confined to cases of ligation of a vein, but may result from any cause which produces obstruction, such, for instance, as tumors of rapid growth, or the presence of two or more clots which invade the vein at different parts of its course.

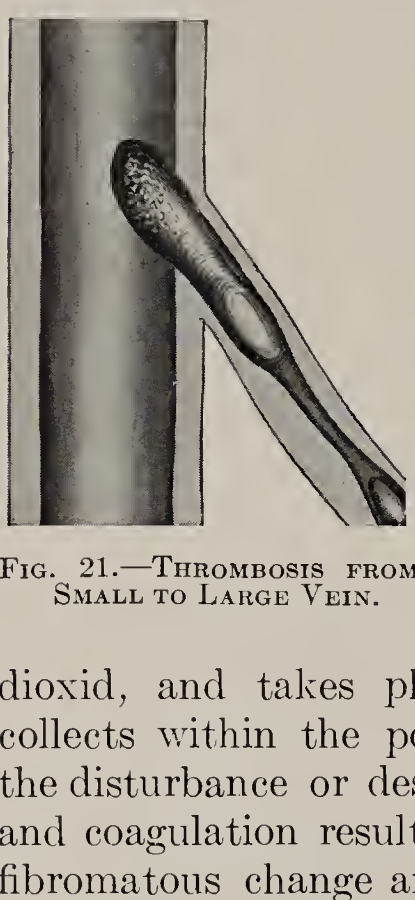

Fig. 21.—Thrombosis from Small to Large Vein.

Thrombosis.—The retardation of the current of blood in the veins may also produce thrombosis. This **dilatation thrombosis** occurring in varicose veins is the result of over-accumulation of carbon dioxid, and takes place more particularly in situations where the blood collects within the pouches formed by the valves of the veins. Here, also, the disturbance or destruction of the leukocytes sets free the fibrin ferment and coagulation results. These **valvular thrombi** most frequently undergo fibromatous change and calcification (see Phleboliths, page 101).

Finally, a thrombosis is observed with advancing years after debilitating diseases, to which the name **marasmus thrombosis** was given by Virchow. With the lessening of the cardiac impulse, the influence on the weakened circulation is such as to produce coagulation at certain points in the venous system. The diseases of greatest interest to the surgeon, which give rise to this condition, are particularly those which arise from infectious processes, as the traumatic septic fevers. In these, as well as in some other diseases resulting from infection, it is believed that the influence of the infectious agents in the blood is such as to set free the fibrin-forming ferment, which induces coagulation under circumstances favoring retardation of the blood-current. The thrombi which are thus produced are usually of the valvular variety at the start, but they may easily advance into the lumen of the vessel, or extend to the next collateral branch (**extension thrombi**). The

favorite sites for these thrombi are the femoral, the profunda, and the common iliac vein. The large veins in the muscles of the thigh, as well as the network of veins in the lesser pelvis, are likewise occasionally involved.

In the autopsy room are frequently found venous thrombi which have occurred after death. These **postmortem thrombi** are easily distinguished from those occurring during life by reason of the fact that they are not closely connected to the vessel wall. On the contrary, they are either loosely connected to the intima or not connected to it at all; in addition, they are of softer consistency and darker in color than true thrombi. Where the latter occur shortly before death there is a possibility of error, but their lighter color will probably serve to aid in the discrimination. The longer the interval between the formation of the thrombi and the death of the patient, the more intimately adherent to the vessel wall will the former be found to be.

The **prognosis** of thrombosis relates principally to the dangers which arise from the tendency of portions of the fibrinous mass to loosen and to be transported to other parts by the circulation. These dangers are increased by the possibilities of septic conditions and suppuration, particularly in phlebitis from injury to veins. The danger of transportation of portions of thrombus arises particularly from the tendency on the part of extension clots to have their terminating extremities, where exposed to the current of blood in the collateral branches, detached and swept into the general circulation. These are carried in a centripetal direction to the right heart, unless they are arrested *en route*, where they pass into the pulmonary artery and are finally deposited into the lungs. The discussion of the disturbances which may result from displaced portions of thrombi will be found in the paragraph on embolism.

Venous Stasis and Its Consequences.—Obliteration of the lumen of a vein either by ligation or by pressure from neighboring inflammatory conditions or neoplasms, unless the collateral circulation is established at once, produces decided disturbances in the capillary area from which the obstructed vein receives blood. The changes which occur, this description being based on observations of the process as it takes place in the web of the frog's foot on the stage of the microscope, are as follows: The smaller veins and capillaries become filled to their utmost capacity; the arteries continue to supply blood to these, its escape, however, being prevented by the obstruction. Each systolic heart movement sends a wave of impulse into the already overfilled area, but in the intervals of diastolic pause between the heart-beats this wave of impulse recedes in the capillary area. The effect of this is to give a to-and-fro movement of the blood-corpuscles. This wave results from the fact that when the increased tension on the somewhat elastic vessels is lessened by the relaxation of the heart muscle (diastole), these force some of their contents back against the arterial column. After twenty-four hours or less of this fruitless effort on the part of the arterial current to force the blood through the capillaries, the watery constituents of the blood are forced through the vessel walls and into the perivascular spaces. At the same time the red blood-corpuscles are forced through the walls of the vessels in greater or lesser quantity, and **diapedesis of the red blood-corpuscles** occurs (Cohnheim). Coincidentally the capillaries increase greatly in size. The escape of the blood-serum into the tissues resulting from the permanent pressure exerted by the arterial column causes the red blood-corpuscles to accumulate in a homogene-

ous mass, in which the individual corpuscles can no longer be recognized. Those which have escaped through the vessel wall, however, may be seen lying in the perivascular spaces. The view that **hemorrhage by diapedesis** occurred was held by the older writers, but subsequently denied, the theory being rejected in favor of **hemorrhage by rupture of the vessel** as the exclusive method of escape of the red blood-corpuscles.

If the pressure continues to obstruct the circulation, whether this occurs from the application of a ligature, as in Cohnheim's experiments, or from the pressure of a neoplasm or inflammatory processes, the serum is forced from the interior of the vessels into the perivascular spaces, and the condition known as **edema** results. The pressure being continued, the serum is forced into the rete Malpighii, and blebs or blisters may thus arise in venous stasis. The slightly reddish or deep straw color of their contents is due to the presence of greater or lesser numbers of the migrated red blood-corpuscles; in less severe cases the fluid is identical with pure blood-serum. In extreme and rapidly occurring cases of venous stasis the migrated red blood-corpuscles in the connective-tissue spaces may be grouped together; usually, however, they occur in this situation singly. Generally speaking, there is to some extent a collateral circulation established, which permits of a somewhat impaired but sufficient return of the venous blood from the affected area to the blood-current.

The **diagnosis** of venous stasis resulting in edema is made by the presence of the characteristic objective sign of the latter, namely, **pitting on pressure.** The finger being pressed firmly against the soft swelling at the site of the edema, its removal will show the impression left in the tissues, which disappears again in a few seconds. By this manipulation the serum is pressed into the neighboring connective-tissue spaces, and perhaps also into the lymph-vessels. There may occur conditions of edema in which pitting is not produced, on account of extreme tension of the skin and connective tissue. The distinction between edema and inflammatory swelling will be made clearer by attention to the following points: In edema the fluid which accumulates in the tissue is light straw-colored serum in **mild** cases, and reddish colored in **severe** cases; in inflammation this fluid is **plastic lymph** in **serous** inflammation, and **pus** in **suppurative** inflammation. In edema the blood is at a standstill, while in inflammation it circulates through the dilated vessels. In edema the cellular elements found in the perivascular spaces are exclusively the **red blood-corpuscles**; in inflammation these cellular elements consist of **white blood-corpuscles.** In edema the swelling is marked by a local normal or subnormal temperature; in inflammation the swelling is accompanied by a local elevation of temperature.

Venous stasis in small as well as in large vessels may result from obstruction. This occurs more particularly in inflammatory processes, the return circulation being interrupted in several veins at once, and thus the establishment of a collateral circulation is prevented. In small veins the obstruction may result from the filling of their lumina with white blood-corpuscles, the so-called **white thrombus,** or from the filling of these with pus. Here the symptoms of venous stasis and inflammation occur conjointly.

The most constant as well as the most important sequence of persistent venous stasis is that condition of the involved area of distribution known as **gan-**

grene. Coagulation of the blood in extensive capillary regions extending into the small arteries leads to the death of circumscribed areas, as, for instance, that of portions of the foot and leg after injury and thrombosis of the femoral artery. The gangrene which follows burns of the third degree is partly the result of venous stasis. The abundance of fluid in the parts, due to the increased quantity of blood massed within the region implicated, together with the edematous condition present, shows a more or less strongly marked contrast to the gangrene which follows obstruction of the arterial trunks (embolic gangrene). Because of these differences the former is designated as **moist** and the latter as **dry gangrene.** Although in the latter an edematous condition does not occur, yet this discrimination is not quite exact; while in embolic gangrene the peripheral portions are comparatively bloodless in the beginning, yet blood is finally supplied, sometimes in a very short time, and the parts are plentifully saturated with moisture. The invasion of the parts by micro-organisms is a very important part of the process in gangrene, and the appearance of these sooner or later not only originates and hastens the more or less rapid putrefaction of the devitalized tissues, but produces **gangrenous inflammation** of the adjoining living structures.

In the **treatment** of venous stasis the first care of the surgeon is to place the limb in which it occurs on a higher level than the horizontal, in order to aid, by force of gravity, the return flow of blood from the tissues, and to avert the more serious consequences which may result from this condition. Every effort should be made to give the collateral channels time to dilate and thus perform vicariously the function of the obstructed veins. In this manner only can extensive gangrene and edema be prevented. Centripetally applied friction movements or massage may be useful, but care should be exercised in the application of this, for the reason that, though its usefulness in promoting reflux of blood and lymphatic absorption is well established, it may do harm, if applied in the immediate vicinity of the vein which is the seat of the thrombosis, by forcing into the circulation loosened masses of coagula, dangerous embolism resulting.

Gangrene following venous stasis is a most serious condition and demands the utmost watchfulness on the part of the surgeon. The fact should be borne in mind that early and extensive infection from exposure to bacterial influence is very likely to occur. Early provision should be made to prevent this, and to limit it if it has already occurred. The parts should be protected as far as possible by means of a 1 : 1000 solution of sublimate. The repeated application of crude pyroligneous acid (Simmons), from which the acetic acid of commerce is obtained, or diluted acetic acid, is useful as an antiseptic and stimulant application, particularly where the entire limb is involved. By these measures putrefaction may be sometimes prevented, the dead mass becoming **mummified.** Immediately on the appearance of the line of demarcation separating the dead from the living tissues, and under some circumstances even before this, amputation of the limb should be performed. Patients not infrequently succumb to metastatic pyemia, in spite of every effort.

Embolism.—Embolic processes, to which frequent references have been made in the preceding paragraphs in connection with the transportation of

corpuscular elements, portions of fatty or calcareous degenerated arterial intima, or of decomposed thrombi, may be divided for purposes of study into two groups. In the first of these the embolus originates from the left heart or some portion of the arterial trunk system; the second includes those cases in which intravenous thrombi furnish the material. Of the first-named group, surgically speaking, the most important conditions are those which include **embolic gangrene** of the lower extremities, particularly that of the toes, foot, and leg, the so-called **senile gangrene.** In the second group the emboli are derived from the small veins and are forced by the return circulation into the large veins, or are formed in the latter, and portions thereof are carried into the venous trunks. In either event they are usually carried to the right heart and thence into the pulmonary circulation. Here, as a rule, they lodge, though smaller emboli containing infectious material may pass through the pulmonary artery and its branches, and gain access to the general arterial circulation.

The immediate result of the arrest of an embolus derived from an endarteritis is the filling of the vessel in which it lodges, and which is thus plugged (**obstructive embolus**). The area of distribution of the obstructed vessel, in the absence of an immediately established collateral circulation, is at once deprived of its blood-supply. The failure of the collateral circulation may be due to an endarteritis deformans in the neighboring vessels which prevents them from supplying the requisite amount of blood, or to a weakened circulation in feeble individuals, or to both. Necrosis of the starved-out area supervenes, and the condition known as **embolic infarction** follows. These infarctions are usually wedge-shaped, the base of the wedge corresponding to the first ramification of the vessels, while its point lies in the direction of the obstructed artery (**cuneiform infarctions**).

A capillary hemorrhage about an infarction sometimes occurs, and for a long time it was thought that this was the primary condition, and not the result of the embolic infarction. The true explanation of its occurrence is as follows: The anemic condition of the excluded area having existed for a short time, the capillaries in the neighborhood, in response to the augmented blood-pressure, dilate and send **arterial** blood into the former, through numerous anastomoses. The obstruction which the blood meets in its attempts to permeate the infarction leads to stasis within these dilated arterioles (**hyaline thrombi,** Recklinghausen), still further impeding its progress, and the red blood-corpuscles are forced through the wall of the vessel. These capillary hemorrhages are found in situations where the blood-supply is particularly rich and the freest anastomoses exist (lungs and spleen); on the other hand, where these conditions do not obtain, infarctions occur without capillary hemorrhages (kidney and brain).

In addition to the mechanic effects of embolism, this condition is likewise of importance in connection with the transportation and deposit of infectious material at the points of obstruction, or where emboli become adherent; here new colonies of bacteria develop in consequence. This, the **infectious embolus,** it is believed, becomes the bearer not only of pathogenic germs (see Pyemia) in the ordinary sense of the term, but likewise of the cell-elements of certain malignant tumors.

INJURIES AND DISEASES OF THE LYMPHATIC VESSELS AND LYMPHATIC GLANDS

Injuries of Lymph-vessels.—Any injury of the soft parts necessarily involves injury of the lymphatic vessels. The walls of these are so attenuated and their lumina so small as to escape notice. The escape of lymph is so slight that it is masked by the flow of blood. Some hours afterward, however, this is noticeable as a part of the wound secretion, which is composed of lymph, connective-tissue fluid, and blood-serum, originating from the vessels involved in the venous stasis. In some situations, however, such an amount of lymph may escape as to constitute a genuine lymphorrhagia, notably in the axilla and inguinal region, where the principal lymph-vessels of the extremities join those of the trunk.

Contusions in situations where the muscular structures are closely adjacent to the skin may result in a rupture of a sufficient number of lymph-vessels to constitute a **subcutaneous lymphorrhagia.** Most of the reported cases of this condition have occurred in the lumbar region, and have resulted from the contact of some heavy object with the body, the force being applied in a slanting direction. As pathognomonic signs are to be mentioned the following: (1) well-marked fluctuation immediately occurs, and persists, inasmuch as the contents of the swelling do not become solidified; (2) the exploring trocar demonstrates the presence of a clear, slightly yellow fluid; (3) pain and febrile action are generally absent.

The **prognosis** is favorable. The **treatment** consists in the application of a pressure bandage. Should the condition persist and require operative interference, especially careful aseptic measures should be taken, for the reason that even slight infection under these circumstances may lead to widespread septic conditions.

Injury of the Thoracic Duct.—The thoracic duct may be injured operatively in the neck, and by gunshot and stab wounds in this situation and in the thorax. Operative injuries are recognized by a copious flow of milky fluid during digestion, which coagulates spontaneously when exposed to the air, and of clear fluid during fasting. Intrathoracic injuries of the duct usually lead to accumulations of chylous fluid in the pleural cavity, and are frequently fatal through inanition.

The **prognosis** in operative cases is more favorable (14 recoveries in 15 cases, Allen and Briggs). The **treatment** consists in compression, which is usually successful. Ligation of the distal end may be attempted; a pair of valves on the proximal end stops the flow of chyle from that direction. A collateral circulation is usually established.

Obstruction of the Thoracic Duct.—This may arise from the pressure of tumors from within, or from growths springing from the walls of the duct. It may also have its origin in inflammatory conditions of the duct leading to stricture, and in impaction of filaria. Thrombosis of the left innominate vein, or of the duct itself, and the backward pressure of blood in the subclavian vein in cases of tricuspid insufficiency, may also cause obstruction. When the obstruction is in the lower part of the duct, it is usually compensated for by the establishment of a collateral circulation. This failing, general lymphangiectasis may follow. Transudation of chyle or its escape from rupture of

the duct leads to infiltration of the tissues. Or, the chylous fluid may collect in the cavity of the peritoneum (**chylous ascites**) or in the pleural cavity.

Normal lymphatic glands are not, as a rule, visible in wounds or during operations, on account of their very small size. Under certain pathologic conditions, as, for instance, in the presence of certain neoplasms requiring operative interference, these glands are removed when discernible. The part which these structures play in the removal of effused blood after subcutaneous injuries is an important one. Red blood-corpuscles, in the course of this resorptive process, are carried by the lymph-current to the reticulum of the lymphatic glands and accumulate within them (*vide infra*).

Inflammation of Lymph-vessels (Lymphangitis).—The relation of the lymphatic radicles to the pathologically altered current in cases of inflammatory processes permits the admission into these of free bacteria, as well as of those inclosed in cells. The lymph-current may become obstructed in the radicles by the corpuscular elements added to the lymph, or these may be carried on to the next adjacent lymphatic glands; the latter condition occurs in the majority of cases. The blood-corpuscles carry the infectious material, and act to obstruct the current. The rôle which they play in inflammatory processes is therefore a twofold one: (1) they may transport agents to distant parts; or (2) they may themselves become infected from contact with infectious material. Or, what happens more frequently, the nearest lymphatic glands become infected. Inflammation of the lymphatic channels speedily follows this infection, and lymphangitis is the result. If this occurs in the radicles, it is known as **reticular lymphangitis,** and if in the trunks, as **tubular lymphangitis.** The first-named form of the disease consists of a circumscribed patch of reddened and edematous skin, and is frequently seen in the neighborhood of a focus of infection (**erysipeloid** of Rosenbach), which may persist and even be propagated after the entire disappearance of the primary infection. This is the variety usually present in instances of somewhat mild infection, though it may be seen in connection with a virulent infection as well, in which case it is soon followed by the tubular variety. In erysipeloid or reticular lymphangitis it has been thought that a specific spore-bearing organism, derived from decomposing animal matter, was the cause of the inflammation (Rosenbach). The presence of the bacteria, whatever their form, within the lymph-channels, particularly those which cling to the walls of the radicles, produces coagulation and consequent formation of thrombi. These inclose bacteria which, in their turn, infect the thin walls of the lymph-vessel, and through these the surrounding connective tissue. In this manner a reticular lymphangitis and **cellulitis** are combined; this is the form most commonly observed, and constitutes a form of erysipelatous inflammation; it is due to the invasion of the lymph-channels, either from a wound surface or through a sweat-gland or hair-follicle, by **Streptococcus erysipelatis** (see page 27). A more than usually virulent form of infection causes rapid spread of the inflammation, and a tubular lymphangitis is present. Here the thrombi, when superficially situated, may be perceptible to the touch as a hard cord; the connective tissue of the sheath of the lymph-vessel becomes early infected and inflamed, and the red stripe or streak which is then observed serves to identify positively the seat of the disease. A number of these thrombosed lymph-vessels, with their accompanying perivascular stripes,

are observed running parallel to one another, and extending from the reticular form immediately adjacent to the primary focus to a considerable distance in a centripetal direction. In case a considerable number of lymph-channels are involved, **lymphostasis** occurs, and a certain amount of edema complicates the already existing inflammatory swelling.

The formation of thrombi in lymph-channels differs essentially from that which occurs in blood-vessels (page 102), dependent, as it is, on the inflammatory process itself, and resulting from the excessive entrance of bacteria within the lymph-vessels, whereby a rapid extension of the disease is caused. Despite this, however, these thrombi are more rapidly resorbed than those which occur as intra-arterial and intravenous thrombi, for the reason that they are in intimate relation, on all sides, with resorbing collateral lymph-channels. This is the usual method of their disappearance. Exceptionally **suppurative inflammation** and the formation of **abscess** occur; when this happens, the abscesses are usually seen in circumscribed areas, and quite commonly, singly as well. The strip of redness at the site of the lymphangitis enlarges, and finally a fluctuating swelling appears. It is questionable if so-called organization of these thrombi ever occurs. Certainly cicatricial development in the connective tissue along the line of the previously involved lymphatic vessel has never been demonstrated.

The **prognosis** is not particularly affected by the formation of an abscess in the course of a lymphangitis, as compared with the dangers which arise from suppurative inflammation in wounds. On the contrary, a rather favorable influence may be exercised by the formation of abscesses under these circumstances, as these are quickly circumscribed and form a ready means of eliminating the infective agents which have found entrance into the lymph-channels.

In the **treatment of lymphangitis** the one thing to be borne in mind is the fact that its extension depends on the combined presence of septic agents and open lymph-channels. The treatment, therefore, must be of the most rigid antiseptic character. Fortunately the open lymph-channels form a ready means for the introduction of antiseptic agents into the region of infection. When the wound cavity can be reached, if the disease is the result of a wound which has become infected, this should be thoroughly packed with gauze, saturated either with a 2.5 to 5 per cent solution of carbolic acid, or with a 1:2000 solution of corrosive sublimate in 50 per cent alcohol. The best application to the reddened patch of reticular lymphangitis, or the stripes of tubular lymphangitis, is a large compress wrung out of the carbolic acid solution. The addition of tincture of opium, in the proportion of an ounce to a pint, to the solution, and the application of an oiled silk covering to the compress will be found useful. As soon as the more acute symptoms have subsided, the use of mercurial ointment along the lines of thrombi is indicated; in the reticular variety a 20 per cent mixture of ichthyol in lanolin is very useful, locally applied. Abscess cavities along the course of the lymph-vessels should be opened freely and treated antiseptically.

No danger is to be apprehended from displacement of lymph thrombi. Even should this occur, they would be arrested in the nearest lymphatic gland.

Inflammation of Lymphatic Glands (Lymphadenitis).—The relations between the lymphatic vessels and the lymphatic glands are such

as to render the latter liable to become involved in inflammatory conditions of the former. The extent to which this occurs, however, will be in inverse ratio to the intensity of the lymphangitis. The reason for this is obvious. With a high degree of inflammation thrombi form rapidly and the lymph-channels become early obliterated, while in a mild or lesser degree of infection the bacteria will reach the lymphatic glands without meeting with great obstruction. The physiologic function of the lymphatic glands favors the accumulation within their structure of such matter of a foreign character, whether bacterial or corpuscular elements, as may find its way into the lymph-current. The extent to which this may become infected will depend on the intensity of the infection; this may be of every grade of severity, the resulting inflammation ranging from a slight tumefaction and tenderness to a rapid breaking down and suppuration. Chronic enlargement and induration are not infrequently observed, this condition remaining for years without apparently affecting the health of the individual.

The swelling which occurs in lymphadenitis is due to the migration of white corpuscles to the cortex of the gland, and the accumulation of lymph and the formation of thrombi in the gland structure. Besides this, there is a direct inflammatory proliferation of the lymph-cells, equivalent to the migration of the white blood-corpuscles, which are transformed directly into pus-corpuscles.

Suppuration may follow, an abscess of the gland resulting. This may occur when there has been no suppuration at the point of original infection, as not infrequently happens in cases of infected wounds of the fingers. Again, granulating inflammation (syphilitic, tuberculous, etc.) may give rise to secondary lymphadenitis by infection when no suppuration has occurred at the site of the inflammation itself.

Suppuration of the glands may happen early, or a slow breaking down may occur. A single gland is rarely involved, usually the process including a conglomerate mass consisting of several glands. The capsule of the gland is involved in the suppurative process, the latter passing thence to the surrounding connective tissue (**paradenitis**), this being an incident in the course of an unusually severe lymphadenitis. This condition of paradenitis may mask the glandular inflammation to some extent, and may partake somewhat of the characteristics of a phlegmonous inflammation, particularly when it occurs in the loose connective tissue of the neck. Or, abscesses may occur in the tissue outside the gland, the latter, enlarged and infiltrated, lying in the cavity yet not itself involved in the suppurative process. Again, the gland may first become the site of suppurative inflammation to a limited extent, the pus from which finds its way into the connective tissue outside the gland, and collects there, and, by a process of ulceration, points toward the surface. If not evacuated, it finds its way out, and a **fistulous** communication is established leading into the gland. The skin about these fistulous openings is usually adherent to the gland structure underneath, and becomes extremely thin from atrophy due to pressure and the suppurative process going on in the deeper layers of the skin. It becomes quite blue in color, and is very likely to slough if it is made use of as a flap in the operation for the removal of these infected glands. The skin will be found to be loosened here and there from the underlying mass, the center of this undermined portion corresponding to the site of a fistula, of which there may be several leading to the same mass.

In the **treatment** of simple lymphadenitis, in case the point of infection can be reached, the rational procedure consists of the application of antiseptic measures in such a manner as to destroy the primary focus. As a rule, however, this will not be discoverable. The treatment under these circumstances will, therefore, be very unsatisfactory. The injection of carbolic acid or of chlorid of zinc solutions into the inflamed glands has not been followed by very brilliant results. The same may be said of applications and injections of tincture of iodin.

As soon as an abscess forms it should be opened freely. As a rule, the entire glandular tissue, though diseased, is not involved in the suppurative process. If the abscess cavity is simply opened, under these circumstances, incomplete healing, or at any rate a very tedious convalescence, may be expected. The proper course to pursue is to remove thoroughly, with either the knife or the curet, any portion of diseased glandular tissue within reach. The fistulas, which are so frequently observed after spontaneous or incomplete opening of an abscess from lymphadenitis, should all be thoroughly incised and the curet employed to curet out their walls, and diseased gland tissue as well. Skin which has been undermined is to be cut away. The curet is to be applied unsparingly until the connective-tissue covering is reached, when healthy granulations and complete healing may be confidently anticipated. This may be hastened and a better cosmetic result obtained by skin-grafting.

Tuberculous Lymphadenitis.—The chronic granulating and caseating inflammations of the lymphatic glands which go to make up the general picture of tuberculous lymphadenitis form one of the most important diseases to which these structures are subject. The infective agent almost invariably enters by way of the lymph-channels from some peripheral tuberculous focus. Tuberculous lymphadenitis frequently follows the so-called scrofulous inflammations of the skin and mucous membrane, such as chronic moist eczema of the face and scalp, chronic catarrhal inflammation of the conjunctiva, the middle and external ear, the mucous membrane of the nose and pharynx, etc. This accounts for the frequent occurrence of tuberculous inflammation of the glands of the anterior and lateral regions of the neck. The conjoint or sequential occurrences of these last-named conditions go to make up the state formerly known under the name of "scrofula."

Glands in other regions of the body likewise become the subject of secondary tuberculous deposits, such, for instance, as those in the axilla which follow tuberculous affections of the skin, bones, and joints of the upper extremity and those in the inguinal region which follow like conditions in the lower extremity, and the genital organs; the glands situated in the ischiorectal region following tuberculous disease of the lower bowel, or of the skin in the anal region (see Fistula in Ano); the peribronchial glands in pulmonary tuberculosis, and the mesenteric and retroperitoneal glands in tuberculous enteritis.

Lymphatic glands the site of tuberculous infection may either undergo rapid suppurative changes and cheesy metamorphosis, or may remain for a long time as soft semi-elastic swellings, which are freely movable under the skin. In the first named the products of suppuration collect in the capsule of the gland, a paradenitis follows, and the pus finally makes its way toward the surface, emptying itself through fistulous openings on the skin. The second breaks down late, if at all, and cheesy foci are likewise observed

late in the course of the disease. The glands crowd closely together in this form and sometimes attain the size of a hen's or a goose's egg. On section they present a grayish diaphanous appearance; their structure breaks down easily under the finger, and somewhat resembles the contents of the medullary cavities of the long bones, although it is somewhat firmer.

Microscopic examination of the first form shows infiltration of small cells, composed of migrating leukocytes and newly formed lymphoid cells. Between these areas of infiltration, foci of suppuration and cheesy degeneration are found. This is the variety which affects children principally. The second form, that in which an apparent quiescent state is maintained, is the tuberculous lymphadenitis of adolescence; this appears by preference in the cervical and axillary glands.

As regards general or distant infection, the prognosis in the latter form is much more favorable than in the former. In the one the tuberculous agent is localized for a long time, perhaps permanently, while in the other, or in that which affects children, the early suppuration and caseation lead to disintegration and ready transportation of infective agents to distant parts.

Treatment.—As long as these glandular structures remain without breaking down into suppuration or undergoing caseation, comparatively slight danger attends their presence. The difficulty, however, is that the surgeon cannot tell just when either of these processes may be initiated, or what circumstances will hasten their development. A strict surveillance should be maintained, and, in case palpation reveals any tendency on the part of the glands to break down, they should be extirpated at once. Their long persistence in an apparently unchanged condition will awaken suspicion that the central portion is undergoing cheesy degeneration, in which case delay in effecting their removal may mean serious peril to the patient. In the very commencement of the infiltration, injections of iodin may be used with advantage (iodin 1, iodid of potassium 4, water 100; Durante). The injections should be made daily. The dose employed is at first about 3 minims, the amount being progressively increased according to the size of the gland and the effect produced. Every portion of each gland should receive an injection in turn, until all portions of the structure have been treated. Or, injections of a 5 per cent solution of chlorid of zinc into the structure of the gland, particularly the periphery thereof, and the adjacent structures may be employed (Lannelongue). The amount used at each sitting will vary from four to six drops according to the size of the gland, at intervals of from three to five days, according to the pain and local reaction which follow. These measures may be persisted in for several months, particularly if undoubted improvement follows their use. The best results are obtained by proceeding slowly and deliberately. Attempts to hasten the cure by the use of large or more concentrated solutions will, by exciting too great reaction, necessitate abandoning the treatment altogether. A careful watch must be kept for the breaking down of the gland, however, since the treatment may have been begun too late to prevent caseation. The use of ointments of belladonna, mercury, iodid of potassium, etc., or the older methods of painting with tincture of iodin, have now been quite generally replaced by injection methods or operative procedures. Internal medication in the shape of ferruginous tonics, cod-liver oil, etc., may result beneficially by improving the general health; this treatment, however,

should not take the place of the injection or operative treatment, but rather supplement it. (For the technic of extirpation of tuberculous lymphatic glands, see Operations on the Neck.)

Syphilitic Lymphadenitis.—The infection of **syphilis,** like that of tuberculous disease, gives rise to granular inflammation of lymphatic glands. The inguinal glands, situated as they are near the most common point of entrance of the infection, are the first, as a rule, to be involved (see page 197). Other glands may likewise become involved, as, for instance, the epitrochlear and post-cervical glands. It very rarely happens that lymphatic glands affected by the syphilitic virus undergo either suppuration or caseous degeneration.

The **diagnosis** of syphilitic lymphadenitis will depend on the history as to primary infection. In inquiring into this, the possibility of nonvenereal infection with the syphilitic virus should be borne in mind. The **prognosis** depends on that of the general infection. The glandular involvement is not such as to excite alarm. The **treatment** will coincide with the general treatment of syphilis (see page 199). The suppurative form of bubo following the venereal sore, known as the **soft chancre** or **chancroid,** does not depend on syphilitic infection, and, therefore, is to be treated as a simple suppurative lymphadenitis.

Leukemic Hyperplasia of the Lymphatic Glands.—Chronic inflammation, or chronic hyperplasia of the lymphatic glands, affecting almost equally all parts of the gland, lymphoid cells, and reticular structure, accompanies the disease of the blood known as **leukemia.** This disease does not fall within the province of the surgeon, but is referred to in this connection for the purposes of differential diagnosis. The glandular swellings occur in the region of the neck, axilla, groin, and other regions to such an extent as to form tumor masses; the glands remain freely movable and discrete. Hyperplasia of the lymphoid tissues of the body generally takes place, this occurring as nodules in the intestines, liver, and spleen. The latter may be palpably enlarged. Increase in the number of the leukocytes in the blood is the distinguishing characteristic of the disease, these sometimes equaling in number the red corpuscles, which latter are generally decreased. The course of the disease may be slow or rapid; in the latter case an infectious process is suggested. Anemia is a marked symptom.

The **diagnosis** depends on the blood-examination. Proportionate increase of the leukocytes in this disease presents a marked contrast to the absence of this symptom in the only affection with which it is likely to be confounded, namely, Hodgkin's disease or pseudoleukemia (*vide infra*). Otherwise the two have many points of resemblance.

No surgical treatment is indicated in cases of glandular enlargement occurring in the course of leukemia. In the present state of our knowledge the extirpation of these glands is as irrational as extirpation of the spleen, once advocated in this disease. Besides the difficulties of arrest of hemorrhage, which is specially noticeable in leukemia, a positive contraindication is to be found in the fact that the disease on which the local conditions depends can be neither cured nor arrested by this means.

Progressive Multiple Hypertrophy of Lymphatic Glands (Hodgkin's Disease); Pseudoleukemia.—This disease, sometimes called **malignant lymphoma** (Billroth), occurs in adolescence and middle life, and is

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characterized by an enlargement of the lymphatic glands, first in the neck, and subsequently in the axilla and inguinal region. Other systems of lymphatics become affected, and the disease may finally involve the lymphoid tissues generally throughout the body. It is observed more frequently in the female than in the male. Single glands frequently enlarge to the size of an orange or the fist, constituting in the neck a characteristic deformity. Other and neighboring glands are afterward affected, these latter becoming attached to those first involved, as well as to the underlying skin, by a low grade of inflammatory action. The masses thus formed give rise to more or less circulatory disturbances in the intracranial organs by pressure on the veins, as well as to dyspnea and dysphagia by pressure on the trachea and esophagus. The spleen has been known to be enlarged, and the tonsils and lymphatic apparatus of the intestine as well.

Both the **etiology** and the **essential pathology** of this disease are very obscure. There can be no doubt that it is an infectious disease, but the special microorganism which produces it still remains undiscovered.

The principal difficulty in the **diagnosis** of Hodgkin's disease is the liability to mistake it for tuberculous lymphadenitis, which it may resemble very closely in the beginning of the attack, for leukemic hyperplasia of the lymphatic glands, and for sarcoma of the lymphatic glands. The rapid extension of the disease to other and distant groups of glands, with absence of suppuration and caseation, will assist in differentiating it from tuberculous lymphadenitis. In making this diagnosis aid may be obtained, where practicable, by the microscope, tuberculosis being excluded in the absence of the characteristic bacillus. Lymphosarcoma may be excluded by the fact that in this latter affection there is an early tendency on the part of the disease to proliferate beyond the boundaries of the gland structure and invade the surrounding tissues. Large tumors thus developed cannot be traced by palpation to the lymphatic glandular tissue, while, on the contrary, in Hodgkin's disease the mass can almost invariably be so identified. Finally, in lymphosarcoma there is sooner or later an involvement of the skin in an ulcerative process.

The **prognosis** is very unfavorable; in its later stages it produces almost invariably a fatal result by the supervention of extreme anemia. The only **treatment** which, up to the present time, has seemed to have any influence on the disease is the administration of arsenic. In the few cases reported in which success has resulted from the use of arsenic the treatment was generally commenced early in the disease, and was continued over a long period of time. From 5 to 10 drops of Fowler's solution (liq. potass. arsenitis, U.S.P.) or corresponding doses of arsenious acid may be employed daily. Operative interference here, as in leukemic hyperplasia of lymphatic glands, is not to be recommended. The Röntgen ray treatment is said to have favorably influenced some cases.

INJURIES AND DISEASES OF THE NERVES

Contusions of Nerves.—In a severe case of contusion of a nerve the pathologic changes are quite similar to those which follow section. In cases of less severity there are points of difference which relate chiefly to existing conditions of the nerve itself. Thickening of the neurilemma at the point of injury,

caused by a collection of round-cells and spindle-cells, occurs after contusion (Erb), which interferes with the process of regeneration, and, in the course of a few days, the Wallerian degeneration sets in and the medullary substance degenerates; the axis-cylinder is also apparently implicated in the degenerative process (Tillaux). It is asserted that the axis-cylinder remains intact in both the central and the peripheral ends in slight injuries, in which paralysis is complete, though temporary (Erb), as in the so-called **"Saturday-night paralysis."** This is observed in persons who in the course of a debauch fall asleep in a chair with the arm resting across the back of the latter in such a manner as to cause long-continued pressure on the nerves in the axilla. The lesion probably involves slight hemorrhage in the sheath. But few fibers are separated, and a large proportion of the disturbances are mechanical, involving simply a displacement of the semifluid contents of the tubules (Weir Mitchell). Here degeneration does not occur.

Contusions of nerves may be slight or severe, and the symptoms arising therefrom will therefore vary. In fact, a contusion of the soft parts can scarcely occur without some nerve contusion resulting, but this relates to the branches of distribution, and not to nerve-trunks, which alone are included in the present consideration.

In the milder cases no more serious symptoms ensue than some pain at the injured point, and tingling and benumbed sensations referred to the periphery, combined with real or imagined subjective sensations of heat. These symptoms pass away rapidly, as a rule; as, for instance, in the well-known accident in which the ulnar nerve is pressed against the inner condyle of the humerus by a blow on this part of the arm. They may remain, however, particularly the tingling, for several days. The symptoms may persist and chronic neuritis, with neuralgic and shooting pains, supervene; trophic changes are finally established. In more severe injuries complete paralysis and anesthesia of the parts supplied by the damaged nerve ensue. This condition may pass away rapidly, may remain for variable periods of time and still be followed by slow but decided improvement, or it may become permanent. Recovery, however, is the rule.

Severe crushing of long portions of nerve-trunk, such as is sometimes seen in machinery and railroad accidents, explosions, etc., causes considerable and sometimes severe **shock.** This is characterized by a weak and small pulse, pallor of the surface, and cold skin and extremities. Slight disturbances of the sensorium are present; rarely complete loss of consciousness ensues. It is extremely difficult, however, under these circumstances, to determine how much of the shock is due to the nerve lesion and how much to the loss of blood which almost invariably accompanies these injuries.

The **treatment** of contusions of nerves consists in placing the parts at perfect rest; if there is much pain, this should be relieved by an anodyne. Later on the paralyzed muscles and anesthetic skin should be galvanized or faradized, and massage or vigorous friction applied. In case chronic neuritis supervenes the nerve may be exposed at the seat of injury, and if adhesions are found to be present these should be broken up by nerve-stretching (Bowlby).

Other nerve injuries arise from pressure, such as **crutch paralysis.** This is liable to occur in those who are unused to these artificial aids to progression;

it is rare to meet with examples of it among those who have been in the habit of using crutches. The symptoms are numbness and tingling in one or more fingers, followed by weakness and loss of power in the arm and forearm. Complete paralysis may follow persistent efforts to use crutches. The duration of the symptoms will depend on the extent of the mechanic disturbance of the nerve-trunk and the parts involved. The sensory symptoms occur first and are the first to disappear. The paralysis affects some muscles more than others, and hence some recover more rapidly than others. The final outcome of the condition is, as a rule, recovery.

Pressure on the nerves during sleep gives rise to symptoms almost precisely like the foregoing. Here the prognosis does not seem to be so favorable, for, while the sensory symptoms pass away early, the motor paralysis disappears more slowly, and may become permanent. The pressure from the too prolonged application of an Esmarch's **elastic tourniquet** during operations on the extremities may cause paralysis; so, too, holding the arm in a forcible manner, or allowing it to rest against the hard and sharp corner or edge of an operating table during profound anesthesia, may give rise to similar loss of function. Compression by tumors, cicatrices, etc., as well as pressure in bony canals through which certain nerves pass, occasionally gives rise to similar paralyses.

The **treatment** of pressure symptoms resolves itself, to a great extent, into a removal of the cause. Where other treatment is necessary, galvanism, friction, etc., are useful. If, in spite of treatment, the symptoms persist, showing the presence of adhesions, and perhaps some thickening of the trunk itself from chronic neuritis, free exposure of the nerve is indicated, which is to be freed from surrounding adhesions and stretched.

Division of Nerves.—The first change noticed after division of a nerve is a retraction of the sheath and a spreading out of the myelin over the cut ends, which in a few days become united by a gray translucent tissue. The further changes depend on the distance to which the cut ends finally retract. The nerves possess some elastic fibers in the neurilemma, and the distance between the cut ends increases for several days at least. If a space of a fourth of an inch or more intervenes, or if this amount of nerve tissue is removed, regeneration is prevented unless the ends are brought together by artificial means. The ends being left separated for the distance mentioned, the space is filled by cellular granulation tissue containing vessels, which in turn becomes a fibrous cord devoid of nerve tissue. The ends of the nerves undergo degenerative changes in the meantime (Gluck). These changes, however, differ in the two ends. In the case of the **peripheral end** the degeneration commences within a day or two of the injury, and continues until, within two or three weeks, the nerve has undergone complete atrophy. The degenerative changes are marked by destruction of the myelin, multiplication of the nuclei and their encroachment on the medulla, and loss of continuity of the axis-cylinder. In the **central end** the principal difference relates to the axis-cylinder, which remains intact. The nuclei likewise multiply and increase in size, but, instead of encroaching on the medulla, they remain flattened against the sheath of Schwann. An infiltration of white blood-cells into the nerve substance occurs. The upper end of the nerve becomes bulbous. This has been particularly noticed in stumps after amputation. These bulbs were

formerly believed to be composed of simple fibrous tissue, but it is now known that they contain new nerve-elements as well, or fully developed nerve-fibers which replace the altered distal portion of the cut nerve (H a y e m).

The pain caused by a division of a nerve-trunk is inconsiderable; the patient will usually refer to the skin wound whatever pain is felt. Numbness and tingling cause more anxiety than the actual pain. In civil practice **shock** is not a prominent symptom of nerve division, although in military practice, in which the nerve is divided by a missile or projectile, the shock may be considerable. **Loss of muscular power** and of the **sense of touch** immediately supervene, and continue as long as the nerve remains divided. **Sensation** may be affected in many ways; there may be loss of sense of touch and of temperature; analgesia, hyperesthesia and anesthesia, and various other abnormal sensations, such as prickling, tingling, numbness (paresthesia), etc., may be present.

The **thermal sense** is generally lost in proportion to the loss of the sense of touch, and extends over about the same areas as the latter. It may be altogether absent. Patients exhibit no appreciation of heat and cold as applied to the surface in some instances in which complete anesthesia is not present.

The **anesthesia** following a nerve injury varies in extent, and is quite difficult to estimate. The distance at which the two points of a pair of compasses can be distinguished on the affected surface, as compared with the distance at which they can be distinguished on a corresponding portion of the body on the opposite side, is the best means of testing the tactile sense. The sense of locality may also be diminished or lost. Error may be avoided by light touches of the compass points arising from vibrations conveyed to surrounding and sensitive parts. The application of friction tests should be carefully applied for the same reason. In making the examination the condition of the skin should be taken into account. The hand of a working-man, for instance, in conditions of health is sometimes so insensitive as not to recognize contact of any kind.

Complete and permanent anesthesia need not necessarily occur in the area of distribution of a sensory nerve, even in complete section of the nerve-trunk. In given cases it is difficult to determine in case of returning sensibility whether the improvement is due to nerve anastomosis or to true nerve regeneration, and only an examination of the ends of the divided nerve can decide the question. It is probable that neighboring nerve branches, passing within the area of distribution of the affected nerve, convey sensation from that area. In recent cases and in indubitable retraction of the divided nerve ends the occurrence of sensation in the affected area can be attributed only to nerve anastomosis. The importance of differentiating these two causes of returning sensibility is apparent when the question of operative interference and its results is to be discussed. The reaction which the muscles affected show to the different electric currents will likewise govern the prognosis. The persistence of the reaction of degeneration for a period longer than six months, during which time the degenerative process is going on, and at the end of which regenerative processes may be expected (W a l l e r), will be usually followed by further changes of a decidedly hopeless character.

Trophic changes are chiefly of a degenerative nature, though they may be combined with inflammatory conditions. All of the changes grouped under this head are not present, and some of them are of very infrequent occurrence. The trophic changes include the glossy and atrophied skin, almost devoid of wrinkles, and tapering fingers with curved nails, which may be quite soft or abnormally brittle. Eczematous as well as herpetic eruptions may occur. **Ulceration** and **abscess** and even **gangrene** may likewise be present. In parts where hair grows, changes in the latter are very common. There is either an atrophy of the hair-follicles and loss of hair, or the hair becomes very short and brittle. The sudoriferous glands also atrophy, and a dry condition of the parts results. **Changes of temperature** are observed, that of the affected parts becoming elevated, as a rule. Rapid atrophy and degeneration of the muscles occur. The muscles are transformed into fibrous tissue, and deprived of contractility and elasticity; fatty degeneration may be added to this. These changes come on gradually, the muscle wasting in bulk. Trophic changes of the bones are of comparatively rare occurrence. The changes are chiefly of an atrophic character. Shortening of the long bones has been observed. The arthritic changes may occur shortly after the injury, or at a later period. One or more joints may be involved. In case but one is attacked, it is likely to be a large one. The joints become stiff, swollen, and exquisitely tender on touch and motion (Mitchell). Some cases are less severe and of a more chronic type. The exact pathology of these joint lesions has not as yet been determined. The possibility of obtaining restoration of function immediately on the completion of primary union is often disputed, but it occurs, though very rarely. If not more than a quarter of an inch intervenes between the nerve ends, and provided a large amount of cicatricial tissue does not intervene, restoration may take place, after intervals varying from nine months to a year and a half. Restoration has taken place after twenty-one months (Bowlby).

Treatment.—The most rational method of treatment consists in the immediate or **primary suture** of the nerve ends. The attempt should always be made to secure primary union. Even if this fails, the nerve is left in a much better condition for subsequent regeneration, by the prevention of excessive retraction, than would be the case otherwise. (For the technic of nerve suture, see page 354.)

The operation of **secondary suture** is performed some time after the infliction of the original injury, and is most commonly resorted to in cases in which no attempt has been made to secure primary union of the divided nerve. It may be attempted before the wound has entirely healed, or delayed after cicatrization is completed. The sole indications for its performance are the existence of symptoms which show that a nerve has been divided and has not united.

Inflammation of Nerves.—Nerves are not particularly prone to inflammation, in spite of their delicate structure. The pain present in acute inflammatory conditions is partly the result of an involvement of the nerves, and partly due to the pressure exercised by the products of inflammation. Large nerve-trunks are peculiarly insusceptible to acute inflammation in their neighborhood. Phlegmonous suppuration not rarely follows the connective tissue along a large nerve-sheath, without apparent disturbance of the nerve itself.

Suppuration of nerves is extremely rare, the immunity being most probably due to the fact that the laminated sheath presents an almost insurmountable barrier to the diffusion of pus into the interior of the fasciculi (Cornil and Ranvier). A suppurative inflammation involving destruction of a nerve-trunk with paralysis in the area of its distribution is unknown.

In inflammation of nerves the result of traumatism (**traumatic neuritis**) the new cell-formation is continued into the perifascicular connective tissue, and between the layers of the laminated sheath of the nerve fasciculi. The laminae become separated, the fasciculi are compressed, and the nerve-fibers below the diseased spot undergo degenerative changes. The more chronic the inflammatory process, the greater is the tendency to the development of inflammatory products. In chronic neuritis, therefore, a general enlargement of the nerve due to the growth of tissue of new formation between the fasciculi is found. The compression exercised by the latter interferes with the nutrition of the nerve, and degeneration takes place precisely similar to the changes observed in the peripheral end after division.

Neuritis is subdivided into the **localized** and **spreading forms.** The latter form is the more serious.

Neuritis following an injury to a nerve is by no means a common affection. It results more frequently from contused and lacerated wounds than from clean incised ones. Septic conditions of wounds favor its occurrence.

Symptoms.—Pain at the seat of injury, spreading along the sheath of the damaged nerve, and sometimes felt in the neighboring trunks, and fibrillar tremors or spasmodic movements of the muscles are the most common symptoms. Paresis or paralysis and trophic changes in the area of distribution may occur. Sensitiveness to pressure and a hardened feeling along the nerve-trunk are sometimes observed. Extension of the symptoms occurs over a larger area as fresh nerve-trunks or branches are implicated (**spreading neuritis**). In this form the pain is more severe at the commencement, but subsides later on, owing either to a subsidence of the inflammation or to destruction of the nerve-fibers.

The **prognosis** of acute neuritis will depend on the extent of the damage inflicted, as shown by the severity of the symptoms. The length of the attack, as well as the final result, will vary. Recovery may follow or chronic neuritis may ensue.

Chronic neuritis is marked by pain and tenderness along the affected nerve, followed by exacerbations of numbness and tingling pains in the peripheral distribution, dull aching pains increased at night, and sometimes hyperesthesia of limited areas of skin. Trophic changes occur. Some enlargement and hardening along the affected nerve may be perceptible. The muscles to which the latter is distributed are at first the seat of twitchings; later paralysis with wasting occurs. Their electric reactions decrease at the same time. The disease may remain localized or spread, the tenderness in the originally affected nerve subsiding with the occurrence of destructive changes, while the nerves secondarily involved become in time inflamed, tender, and enlarged.

Extension of the inflammation to the spinal cord (**ascending neuritis**) has been observed clinically as one of the sequences of neuritis, the symptoms pointing to inflammation and sclerosis of the cord.

Treatment.—In the **acute form** complete rest, with application of cold (ice-bags) or evaporating lotions, and opium for the relief of pain, are indicated. Leeches and cupping are also recommended. In the **chronic form** mercury or the iodid of potassium is to be administered internally, and anodynes employed. Counter-irritation is useful (thermocautery). Galvanism and faradism may also be employed with benefit. Nerve-stretching may be of service. In aggravated cases, with great suffering and a practically useless limb, amputation may be resorted to. Even this may not avail, the pains persisting in the stump.

INJURIES AND DISEASES OF FASCIAE, MUSCLES, AND TENDONS

Injury and Inflammation of Fasciae.—The fasciae are distinguished by very wide variations in both extent and composition. Many of them are simple planes of connective tissue spread out beneath the integument or between muscular layers, such as the fascia of the neck, perineum, etc. These do not need special study here, inasmuch as the diseased conditions of the fasciae in these regions are almost identical with those of the subcutaneous cellular tissue already described (see page 66). The rigid fasciae, composed of solid transverse fibers, such as the fascia found in the anterobrachial region, the fascia lata of the thigh, and the palmar and plantar fasciae, present certain peculiar characteristics worthy of notice.

Incised wounds of the fascia, if made in a direction parallel to the direction of the fibers, gape but slightly; on the contrary, if made in a direction to cross the fibers, they gape considerably. These points are to be borne in mind when making incisions for the purpose of evacuating pus or reaching an inflammatory focus in the palm of the hand or the sole of the foot. In the latter situation, the fibers run in a longitudinal direction, and incisions in this direction gape but slightly. In the palm of the hand the fibers are placed transversely to the long axis of the part.

Inflammation of Fasciae.—Fasciae and aponeuroses contain comparatively few vessels, and are, therefore, but passive agents in inflammatory processes. They serve as barriers in limiting suppurative processes. In extensive phlegmonous inflammation, and in the burrowing of pus, this does not suffice, for the reason that weak points exist here and there, particularly at localities where blood and lymphatic vessels pass through. At these points pus and other septic products pass from one side of the fascia to the other. It is a noticeable fact, however, that while a subfascial suppuration is quite likely finally to find its way toward the surface, a subcutaneous phlegmonous inflammation, on the contrary, is usually limited, as to depth, by the fascia. This is due in part to the strong pressure exercised by the tense fascia in case there are accumulations of pus beneath. This circumstance likewise favors the absorption of septic material from subfascial suppuration, and increases septic fever.

Inflammatory necrosis of fasciae is quite commonly observed, particularly where a phlegmonous suppuration invades both sides of the fascia. This tendency to sloughy conditions is also explained by the presence in its structure of a relatively small number of blood-vessels. In case of extensive injury and loss of substance, laying bare areas of fascia, granulations spring up very

slowly on the latter; vascularization of the fascia must occur before the latter is able to produce granulations.

Injuries of Muscles.—In injuries of muscles the contractility of the latter play an important rôle. When the fibers are separated in a transverse direction, the wound gapes in proportion to the extent of the division. The application of force by a blunt instrument may result in a separation of the muscular fibers by driving them against the bone underneath, the skin and fascia escaping. Rupture of a muscle may likewise occur without the application of external force (see Injuries of Special Parts). The torn blood-vessels pour out a mass of blood, which fills up the gap between the injured muscular fibers. The connective tissue proliferates rapidly in the coagula and the latter are absorbed, leaving a swelling of exceptionally firm consistency, the so-called **muscle callus,** or muscular cicatrix. In this, muscular fibers may finally develop.

Inflammation of Muscles.—With the exception of some forms of so-called rheumatic affections of muscles (lumbago, etc.), inflammation of muscles is of rare occurrence. In certain conditions of deficient or erratic metabolism characterized by uricemia, **infiltrations** occur in the muscular and subcutaneous connective tissue. There may be considerable interference with the function of parts controlled by the muscles involved, and pain and inability to relax these on motion. The involvement of nerves in the infiltration will lead to painful, paresthetic, and anesthetic areas.

A peculiar variety of hyperplastic inflammation, characterized by the final development of genuine bony plates, affects muscular structures, and is known as **myositis ossificans.** The affection may be traumatic or nontraumatic. Heredity is supposed to influence its production. Osteomas and osteophytes sometimes occur simultaneously. The *x*-ray may be employed to assist the diagnosis. Treatment in the nontraumatic variety is generally useless. In traumatic cases complete excision may give relief (Keen).

Phlegmonous inflammation following the plane of connective tissue between the muscles (the paramuscular connective tissue) constitutes what is sometimes known as **suppurative myositis.** This affection originates, as a rule, in the bony or periosteal structures. While the sheath of the muscle may be invaded by phlegmonous inflammation, and in rare instances the intramuscular connective tissue likewise, the inflammation spreading between single bundles of fibers, it is very exceptional for the muscular fibrillae and sarcolemma sheaths to become involved. It is not an uncommon thing to observe muscular structures intact in the midst of a perfect wreck of tissue, bathed in pus and surrounded by structures involved in suppurative destruction. Small abscesses may be found exceptionally on the belly of the muscles. In **metastatic** or **pyemic infection** abscesses occur near the insertion of certain muscles (flexor carpi ulnaris, quadriceps extensor femoris).

In glanders, particularly in the slowly developing forms, multiple abscesses appear in the muscular structures. In syphilis a gumma of the muscular structure may suppurate, producing abscess.

The migration of trichinae into muscular tissue produces edematous swellings, but these are circulatory disturbances rather than the result of inflammatory irritation.

Sarcomas of voluntary muscles are somewhat rare. The majority of

the cases have occurred in the muscles of the lower extremities. They may occur at any period of life from young adult age to sixty. A localized involvement of the sheath is first observed, the disease afterward extending to the belly of the muscle. The localized induration of a sarcoma of a voluntary muscle may be mistaken for a syphilitic gumma in a patient with a syphilitic history. Invasion of muscle from adjacent sarcomas, particularly of the periosteal variety, is common. It may also occur in sarcoma of the uveal tract following the involvement of the sclerotic, the disease finally infiltrating the muscles of the globe.

Sarcomas of involuntary muscle-fiber are exceedingly rare. Those which affect the uterus have their origin in the endometrium.

Injuries and Diseases of Tendons.—Subcutaneous contusions of tendons are of rare occurrence, owing to the solid consistency of these structures. Aside from incised wounds, the most common injury to which tendons are subject is **rupture** or the tearing off of the tendon at its point of insertion, by excessive contraction. This occurs more particularly in the great quadriceps extensor femoris at its point of attachment to the patella. In modern times not infrequently machinery accidents produce rupture of tendons in the hand and forearm.

Incised wounds of tendons are of rather frequent occurrence. These are observed particularly about the anterior carpal region, arising from suicidal attempts to sever the vessels at the wrist. They are also observed rather frequently in domestic servants as a result of accidentally pushing the hand through the windowglass in cleaning. The posterior metacarpal region suffers among house carpenters, the injury being caused by edged tools falling from a height. The tendo Achillis is sometimes divided in the same way, the falling implement striking the tense tendon just as the individual is taking a forward step with the other foot. **Immediate** and **accurate suture** should always be attempted in order to restore the function of the divided tendon (see page 358).

In **subcutaneous tenotomy** for the correction of deformities, particularly of talipes, a "splice" of tendinous tissue unites the divided ends by means of connective-tissue proliferation. This proliferation originates in the connective-tissue covering of the tendon, a portion of which stretches from one extremity to the other after the division of the tendon proper (Adams). Increased vascularity of the vessels in this connective tissue occurs, but the extravasation of blood from the divided vessels of either the skin or the connective tissue between the divided ends is not essential and may be disadvantageous to the reparative process.

Tendons are not invaded by **suppurative inflammation,** owing to the comparative absence of blood-vessels in children, and their entire absence in adults. Pus-corpuscles may migrate into the nutritive channels, and blood-vessels may invade the tendon during the **granulating process** in the course of repair. This latter circumstance is rather unfortunate than otherwise, as the function of the tendon is likely to be interfered with by the adhesions which form as the result of this vascularization. Still worse, however, is the **necrosis of tendon** which occurs somewhat frequently in the course of a phlegmonous inflammation in the paratendinous structures.

In many localities genuine synovial cavities develop in the course of the

paratendinous tissues, forming a true synovial sheath. The inflammatory processes may attack the synovial lining of the sheaths, constituting the so-called **tenosynovitis.** This synovial inflammation is practically identical with that which occurs in joints, and will be discussed in connection with these structures (see page 151).

Treatment of Inflammation of Muscles and Tendons.—The preservation of the function of muscles is of very great importance, and special care should be taken to prevent burrowing of septic material along the surfaces of muscles and tendons. To this end, early and free incision in spreading septic conditions, whether of phlegmonous inflammation or of burrowing pus, must be made and efficient drainage provided for. Great damage may be inflicted on the function of muscles, even when these are not actually invaded by the inflammatory process, by considerable masses of granulations developing between the bellies of the same, or about the tendinous structures. Cicatricial tissue forms, and this may prevent the contraction of the muscle. The interdependence of the muscular groups on one another, as well as the conjoint action of muscles of the same group, demands the utmost freedom of motion. Muscles of one group, if impaired in their function, limit the usefulness of opposing muscles.

Under these circumstances of impairment of function, due to the effects of intermuscular inflammatory conditions, much benefit may be derived from the employment of passive motion. This may be accomplished at first under an anesthetic, but subsequently the latter may be omitted. Complete flexion and extension being accomplished, the employment of **massage,** conjoined with **systematic passive movements,** constitutes the most efficient means at our disposal. The so-called muscular rheumatism and erratic infiltration are likewise very efficiently treated by massage and faradization. Articles of food containing notable quantities of the purin bodies, which are supposed to stand in a causative relation to the uricemia, are to be avoided, such as certain meats and fish, particularly salmon, the glandular structure of animals (sweet-breads, thymus, liver, etc.), pulse (peas and beans) and asparagus, coffee, Ceylon and India tea, and ale. The usual antirheumatic remedies are useless, and some of the most vaunted, such as salicylate of soda, are positively contraindicated.

Motor paralyses are also benefited by massage. Although somewhat painful in the application, there is no better method of treatment than massage for **muscular hematoma** and **serous effusions** within muscles.

INJURIES AND DISEASES OF BONES

Contusion.—Force directly applied to a bone is felt (1) in its periosteal covering; (2) in its cortical substance; (3) in its medullary substance. Slighter forms of contusion occur, particularly in bones superficially situated, such as the tibia, ulna, etc. In **fracture from direct violence,** contusion and fracture are combined. Fissure of a bone, in the direction of its long axis, occupies a ground midway between contusion and fracture. It does not interrupt the continuity of the bone. Occasionally these fissures assume a spiral direction, and have been designated **spiral fractures** (Fig. 22). They have been known to occur by indirect violence, the patients having been crushed, from above, beneath heavy masses of earth, etc.

Contusion of bone is not, as a rule, an important form of injury. Extravasated blood is soon resorbed; a slight thickening may remain. Very rarely suppurative or phlegmonous inflammation follows. The infection producing this finds its way to the point of injury, either from the skin or through the medium of the effused blood. The latter view is supported by the occurrence of nontraumatic infectious osteomyelitis and of syphilitic affection of bones. Extravasation within the medullary cavity of bone still more rarely results seriously, though, in certain cases, inflammation and suppuration may develop. The course of the blood through the medullary tissue favors the arrest of corpuscular elements between the cells of the latter. (See Traumatic Inflammation of Bone, page 139.)

FRACTURES

Classification of Fractures.—Fractures of bones are divided into **incomplete, complete,** and **comminuted; simple** and **complicated.**

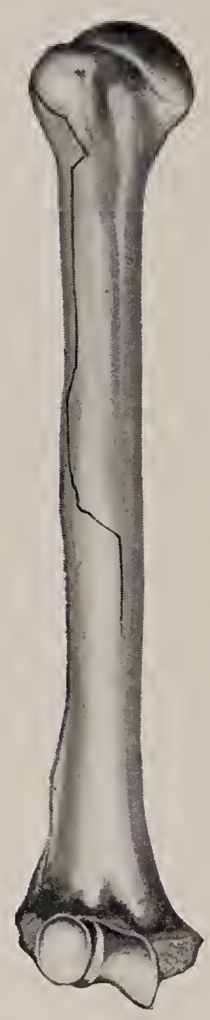

Fig. 22.—Spiral Fracture.

The Relations of Direct and Indirect Force to Fracture.—Fracture may be the result of direct and indirect violence. In the former the force strikes the bone directly, while in the latter it is transmitted through some other portion of the skeleton. When an entire extremity is exposed to the force, it is simply a question whether certain ligaments are to become ruptured and a dislocation produced, or one or more of the bones are to give way. When indirect force produces the fracture, one portion of the extremity is fixed by muscular contraction, and, acting as the fixed arm of a lever, transfers the force to the bone, which gives way.

Seat of Fracture.—The point of fracture, other things being equal, will be at the place of least resistance, and this, in its turn, will depend on the relation of the cortical substance to the medullary and cancellated tissues. The middle of long bones marks the site of the first or diaphysial center of ossification, and at this point the cortical lamellae are strongest and the cancellated structure absent. In the direction of the epiphysis, where later ossification occurs, the cortical lamellae are much thinner, and cancellated tissue is abundant. The long bones, therefore, are more solid, though they are brittle at the middle, and the tissue at the extremities is loosely built up. In indirect force, therefore, it is the upper or the lower third of the bone which yields, while in direct force, received in the middle, the latter gives way. In addition, direct force may produce a fracture wherever it is expended.

The Character of the Force.—A classification of the causes of fracture, owing to their number, is almost impossible. Projectiles from the modern rifle, as a rule, pass directly through the bone; those from the old-time smooth-bore generally lodged within the bone. A partially spent ball may likewise follow the latter course. In the case of the former a "punched out" effect is produced. The ball carries a portion of the bone ahead of it, as a solid punch would make a hole. This occurs more particularly in the diaphysis, where the effect is something like that which follows the passage

of a ball through a window-pane. In the neighborhood of a joint the cushion-like structure of the epiphysis may arrest the ball and cause its lodgment.

In civil life falls are the most common cause of fracture. Here the force producing the fracture depends on the distance which the body falls, the weight of the body, and, in case of fracture of an extremity by indirect force, the length of the lever through which the force is transmitted. **Crushing** beneath heavy objects (falling banks of earth) and **muscular contraction** may also be mentioned. In the case of the latter the bony insertions of muscles are usually torn off. Exceptionally a long bone may be fractured by muscular force, as, for instance, in fracture of the humerus occurring in baseball pitchers.

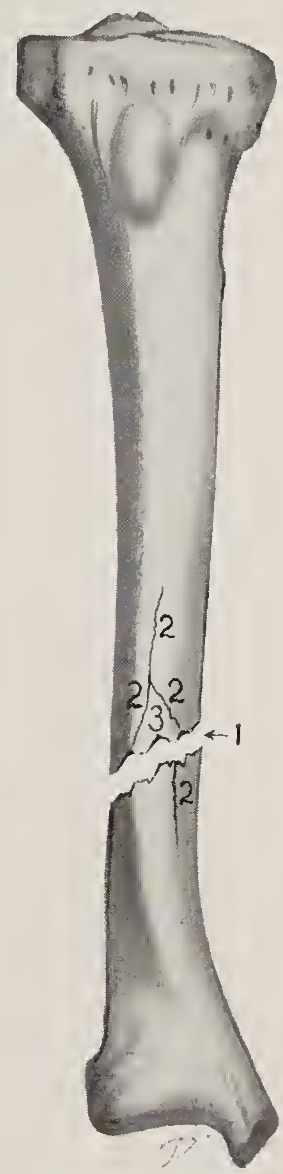

Fig. 23.—An Oblique Fracture with Dentated Surfaces, Splintering, and Comminution.

1, Oblique line of fracture with dentated surfaces; 2, 2, 2, 2, line of fissures; 3, an isolated fragment constituting a comminuted fracture.

Direction of the Line of Fracture.—The line of fracture may be **longitudinal, transverse,** or **oblique.** The first named is rare. Only a direct and very considerable force can produce a fracture of a long bone. A purely transverse fracture is also rare, for the reason that the line of fracture will follow the direction of least resistance, and this differs according to the arrangement of the lamellae. The latter, on transverse section, do not show the same degree of solidity at all points; the line of separation may show a zigzag line for this reason (dentated fracture). From the bottom of the dentations fissures may run in an oblique or longitudinal direction (Fig. 23), according to the direction of the lamellae, constituting a **splintered fracture.**

Comminuted Fracture.—Where several splinters are loosened, or more than two fragments are found at the site of fracture, the latter is said to be comminuted. Brittleness of the bones, great velocity of the effecting force, machinery accidents, and crushing by means of a heavy broad surface, such as the wheel of a railway car, are the common causes of comminuted fracture.

Incomplete Fracture.—The most common form of incomplete fracture is the **subperiosteal fracture.** These occur more particularly in rachitic children with thickened periosteum, the untorn periosteum retaining the fragments in position. Partial preservation of the periosteum also occurs in cases grouped under the head of **epiphysial separation.** This is a true fracture, *i. e.*, it is not a separation at the cartilage of the epiphysis, but of the bony structure at the very youngest layer of the diaphysis. It constitutes the most typic form of transverse fracture. It is not so common as was formerly supposed.

Green-stick Fracture (Infraction).—The inherent elasticity of young bone permits more or less bending before fracture occurs. Bones of children yield somewhat in this way before breaking. This increased elasticity is compensated for, however, by the lessened diameter and diminished cohesive qualities. In this forcible bending of bones which are somewhat elastic, single lamellae give way and a splintered effect, such as follows the forcible bending

of a green twig, occurs (Fig. 24). Green-stick fracture differs from impacted fracture in that, while in the former some of the lamellae give way and others maintain their integrity, in the latter the entire thickness of the bone is traversed by the line of fracture. In this sense, therefore, the **fracture is complete,** though at first glance there is no displacement apparent. This, however, is delusive, as **shortening** of the limb occurs, and there is therefore a **longitudinal displacement** (see page 127).

Complicated Fractures.—Complications of fractures refer principally to the soft parts. No fracture can occur without some injury to the surrounding parts. Those in which a wound affords a medium of communication between the atmospheric air and the site of the fracture are known as **compound fractures.** The term "complicated" is now applied more particularly to those in which important vessels and nerves suffer injury.

Compound Fracture.—The compound variety is the most common of the complicated fractures. Here the communicating wound involves both skin and muscular tissue, except in situations in which the bone is subcutaneous. The wound in compound fracture may be caused by the missile or object which produces the fracture, as, for instance, the bullet in fractures from gunshot injuries, or the toe-calk or heel-calk of a horseshoe in fractures resulting from the kick of a vicious animal. Fractures from indirect force may also be compound, the bone being driven or pushed through. This variety may be properly termed a **perforating fracture.**

Fig. 24.—Green-stick Fracture.

Noncommunicating Wounds of the Skin in Fracture.—Simple wounds of the skin, though not so serious as those which extend to the site of fracture, are still worthy of note. Suppurative inflammation here may prove serious from close proximity to the bone lesion. During the after-course of a fracture a skin wound may arise as a complication, either from faulty dressing or, in case of delirious patients, from attempts to walk. In the former the dangers relate principally to infection from the neighborhood, while in the latter a true perforating fracture takes place.

Rupture and contusions of vessels and nerves form special complications of fractures. In military life these result from gunshot wounds particularly, and in civil life they are more often observed in machinery and railroad accidents. Except under these circumstances they are rare.

In case of recent fracture inspection in the majority of cases reveals a **displacement of the fragment.** The strain placed on the bone at the moment of giving way produces at first a **bend** in the same, owing to more or less flexibility present in all bones. The fracture occurring, the direction of force which produces the bend continues, and deformity at once results. This displacement usually consists primarily of an **angular** flexion in the long axis of the bone (Fig. 25, A). Contraction of muscles, the support given to fragments by surrounding structures, the weight of the portion of the body below the site of fracture, and the rebounding force may individually or col-

lectively operate to prevent angular displacement in the long axis. Angular displacement failing to occur, other forms replace it, as shown in Fig. 25.

The characteristics of each displacement may be seen at a glance. It should be remarked, in connection with the displacement shown at D, that a lengthening of the limb does not occur, but that the separation of the fragments is due to muscular contraction, the bony prominence to which the muscles are attached being broken off.

Impacted Fracture.—Among the peculiar forms of displacement, that in which impaction occurs is to be particularly noticed. Either by external force or by the weight of the falling body, one fragment is driven into the other, and an effect similar to a gomphosis is produced. Impacted fracture occurs

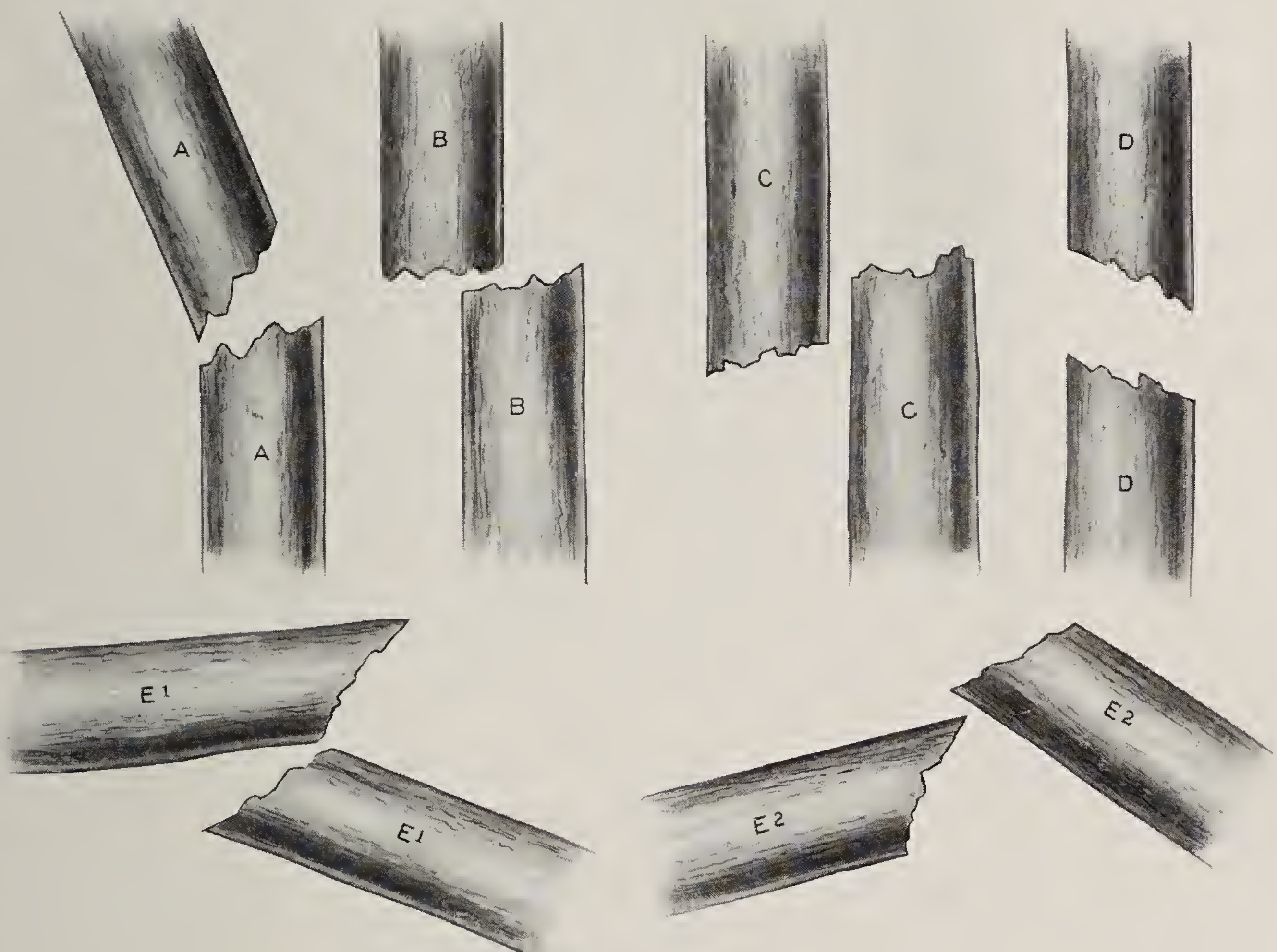

Fig. 25.—Varieties of Displacement Occurring in Fractures.

A, Displacement in the axis of the bone; B, lateral displacement; C, longitudinal displacement with transverse line of fracture and the overriding of the fragments; D, longitudinal displacement with separation of the frag nents; E^1 and E^2, the overriding of the fragments in oblique fracture (modified after Hueter).

particularly at the junction of the cancellous structure and diaphysis of the long bones, and is most frequently observed in the neck of the femur (Fig. 26).

Rotating displacement is likewise observed. This results from the rotation of a fragment on its own axis, the fractured surfaces remaining in contact with each other.

Overriding of Fragments.—A combination of two or more of these forms of displacement may be observed. A displacement in the axis, a lateral displacement, and a longitudinal displacement with approximation of the fragments, constitute the form in which overriding occurs (Fig. 25, E^1).

Mechanism of Displacement.—Whatever displacement occurs, the principal factors in its production are (1) the character of the force; (2) muscular contraction. The primitive form, or that of displacement in the axis, is a

familiar example of the first (Fig. 25, A), while the longitudinal displacement, with separation of the fragments (Fig. 25, D), illustrates the second. In addition to these, two other circumstances enter into the consideration, *i. e.*, the weight of the body, which is to be considered in relation to the occurrence of impacted fracture, and the weight of the extremity beyond the seat of fracture, which may influence the occurrence of lateral and rotating displacement.

Diagnosis of Fracture.—The signs of fracture are (1) deformity; (2) swelling, and perhaps contusion when the fracture is the result of direct force, and a wound in compound fracture; (3) pain and tenderness; (4) crepitus; (5) preternatural mobility; (6) loss of function. Any of these signs may be absent. In examining a suspected fracture we employ chiefly inspection and palpation.

Inspection.—The deformity will depend on the extent and character of the displacement present. In addition to this, inspection reveals the character of the swelling, the extent of the extravasation of blood, and the condition of the skin at the site of fracture. Later on, the swelling, which in the beginning depended on displacement of the fragments and blood extravasation, will be in a measure due to the formation of new tissue, bony and otherwise (see Repair of Bone, page 130). If the extravasation is superficial, the discoloration from changes in the blood-pigment will occur early; if deeply situated, the characteristic blue and yellowish-green discoloration will appear after the lapse of several days. In case a fracture extends into a joint the latter may become swollen from serous effusion or a genuine hemarthrosis may occur.

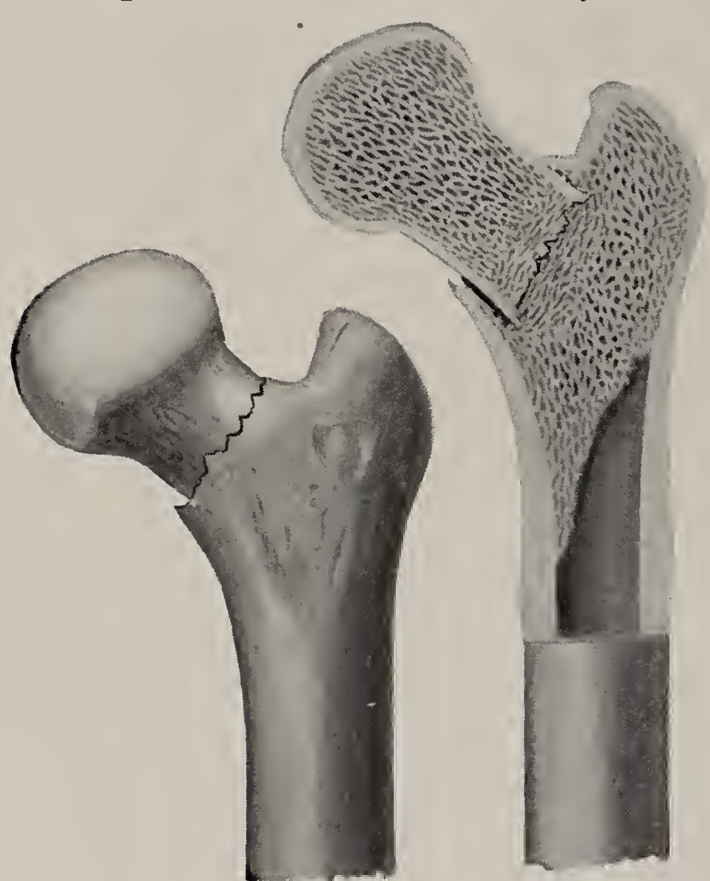

Fig. 26.—Impacted Intertrochanteric Fracture of Neck of Femur.

Direct inspection of the injured bone may now be accomplished by the aid of the Röntgen or x-ray, both for the purpose of diagnosis in doubtful cases and as a guide for the manipulation in adjusting the fragments, the fluoroscope being employed for this purpose. A permanent record of the condition and relations of the injured osseous structures, as well as of the course and completion of the reparative process, is obtained by exposing a sensitized photographic plate to the x-ray, with the injured part interposed, a shadow picture resulting (skiagraphy or radiography).

As a part of the examination by inspection, **mensuration** is employed for the purpose of assisting in the immediate diagnosis and of ascertaining the extent of shortening present when restitution of the fragments is supposed to have been accomplished. In measuring the length of a limb and comparing it with that of its fellow, care should be taken to bear in mind differences which may exist within normal limits. Too much stress should not be laid on

slight differences, for the reason that, in addition to the inability to exclude normal discrepancies, the method cannot be applied with sufficient accuracy to exclude absolutely errors of a half inch or less.

Palpation.—Although inspection will frequently be sufficient to establish the diagnosis, in doubtful cases it is often necessary to employ palpation as well. **Tenderness** is well marked at the line of fracture, and this is of special diagnostic value if none exists elsewhere in the neighborhood. **Crepitus,** a peculiar grating sound and sensation heard and felt when the fragments move upon each other, is elicited by grasping the seat of fracture with both hands, one above and the other below, and moving these in different directions. Slight rotation will often elicit crepitus. This sign is not of so much importance as was heretofore supposed by the older surgeons. It is quite frequently absent; in impacted fracture it cannot be produced. In fracture with lateral displacement it is difficult to elicit it without first reducing the fragments, in which case, for purposes of diagnosis, it is not then necessary. The same may be said of the longitudinal displacements. In all of these conditions its existence is not necessary for purposes of diagnosis. On the other hand, the attempt to demonstrate it is always a source of suffering to the patient and it may do positive damage, as, for instance, in the case of an impacted fracture of the cervix femoris.

Palpation likewise reveals the existence of **preternatural mobility.** The existence of a fracture undoubtedly permits a certain amount of abnormal movement, and this can be demonstrated by the same manipulations as are carried on in ascertaining the presence or absence of crepitus. This sign, like that of crepitus, is absent in impacted fracture and in longitudinal displacements. In case the fracture is near a joint, it is exceedingly difficult to distinguish between preternatural mobility and normal joint movements.

The examination for both crepitation and preternatural mobility may well be omitted until measures have been taken for the application of proper treatment in the case. In some cases, such, for instance, as fractures of the internal epicondyle and the malleoli, sole dependence must be placed on the symptoms of swelling due to extravasation and pain at the site of the injury.

As a further aid in the diagnosis, palpation may determine the number, size, and shape of the fragments. In addition to this, later on in the case, it will likewise be employed to ascertain the extent of functional disturbance of neighboring structures, joints, etc.

Anamnesis.—While the history of the case as obtained from bystanders may be of some avail in assisting in the diagnosis, it should be borne in mind that statements made by the injured person are of but secondary importance, and should receive but little consideration compared with the objective symptoms. Under all circumstances involving doubt, if a reasonably well-founded suspicion of the existence of a fracture is entertained, the case is to be treated precisely as if the diagnosis were positively assured. It is always best to err on the side of safety, in the patient's interest. It is far better for both surgeon and patient that any number of cases in which a positive diagnosis cannot be made, and in which only a suspicion of fracture is entertained, be treated as fractures, even unnecessarily, than that a single case of fracture be allowed to go untreated until irreparable injury is done. The differential diagnosis of fracture and dislocation will be treated of under the head of the latter.

Course of Simple Fractures.—The reparative process in simple fractures includes (1) resorption of effused fluids and particles of destroyed tissue; (2) the formation of callus. The first named is sometimes accompanied by slight fever (aseptic fever of Volkmann) and some lymphatic swelling in the groin or axilla. During the first few days albuminuria and the presence in the urine of debris from the destroyed red blood-corpuscles are occasionally observed (Riedel). **Fat embolism,** resulting from the breaking up of the medullary substance and its absorption by the lymph-channels, from which it finds its way into the circulation, is sometimes observed in connection with multiple fractures or the crushing of a single large bone. The arrest of fat emboli in the pulmonary circulation leads to edema of the lungs and consequent dyspnea, which may terminate fatally. The fat globules obstruct the capillaries of the glomeruli and are excreted with the urine. The supply of fat may be intermittent and occur at different stages of the repair.

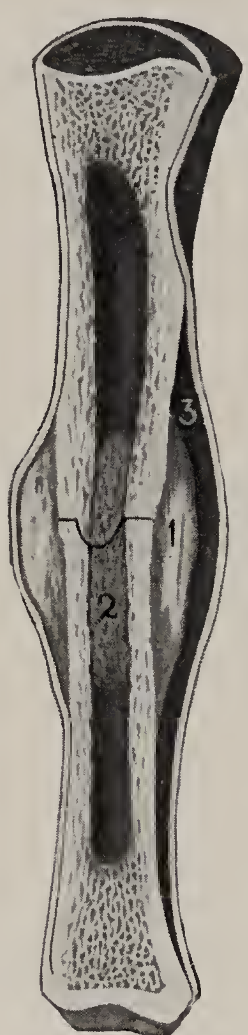

Fig. 27.—Repair of Bone.
1, Periosteal callus; 2, medullary callus or dowel; 3, loosened periosteum.

Callus is formed principally by the periosteum and medullary tissues; the former, however, plays the most important part in its production. During the first few days calcium salts are deposited between the ends of the fragments. In the meantime the torn periosteum becomes reunited and a ring of new formation occurs at the site of the fracture. This is the **provisional callus** (Dupuytren), and is formed by the innermost or osteogenetic layer of the periosteum (Ollier). At the same time the medullary substance forms the **definitive callus** (Cruveilhier). The Haversian canals likewise take part in the production of bone, and to a slight extent the cortical lamellae as well. The process of ossification commences in the newly formed tissue between the fragments; this tissue, together with that furnished by the periosteum and medullary structure, becomes welded together in a solid mass, and the formation of callus is completed.* The length of time which the entire process of repair occupies in man varies from three weeks to as many months. The average time is from five to six weeks.

After the completion of the reparative process, **regeneration of the callus** (Lossen) occurs. This consists in a gradual restoration of the callus to the condition of true bone. Systems of regular lamellae are produced, and the dowel which divided the medullary cavity of the bone into two portions is replaced by true medullary substance. This process occupies a year or more. In fractures involving articular extremities the medullary callus is finally converted into true cancellous structure. In fractures of the neck of the femur the reformed cancellous structure follows the lines best calculated to bear the weight of the body, as in the normal state.

* The terms "provisional" and "definitive" callus are here retained; the terms, however, are not quite exact. Although the outer ring is formed somewhat earlier than the connecting dowel from the medullary substance, yet both alike contribute to the final repair.

The formation of callus and its final change to normal bone are analogous to the process of repair in soft parts when union by first intention occurs. The histologic processes, consisting of cell infiltration, new formation of vessels, and condensation of newly formed tissue, are quite similar. The newly formed bony tissue is the result of the proliferation of existing osteoblasts.* The manner in which the periosteal and medullary newly formed tissue appropriate from the circulation the salts necessary for their proper construction is as yet unexplained. A curious circumstance in connection with this matter is the fact that, under the influence of irritation, particularly that of hematic origin incident to extreme displacement or defective fixation of the fragments, the neighboring structures become the sites of deposits of callus. These deposits are instances of **superfluous callus,** for the reason that they take no part in either the temporary or the permanent fixation of the fragments.

Excessive formation of callus is that condition in which an undue amount of reparative material is formed at the site of the fracture, and is considerably in excess of the requirements of definite repair. Excessive, like superfluous, callus is the result of undue mechanic irritation, such as improper coaptation or insufficient fixation of the fragments. It is formed principally from the osteogenetic layer of the periosteum in transverse fractures. The circumference of the bone may be two or three times in excess of the normal, this being due in part to the displaced fragments, and in part to the necessity for a large mass of reparative material to form bridge-like masses of bone between lateral surfaces, in order to maintain the weight of the body in fractures of the lower extremity, on the completion of the process of repair (Fig. 25, C). In fractures with longitudinal separation of the fragments an excessive amount of callus at first develops in filling up the gap between the fragments (Fig. 25, D). In oblique fractures with overriding of the fragments (Fig. 25, E^1 and E^2) the excessive callus is produced by both the medullary substance and the periosteum.

Considerable impairment of function may result from the presence of excessive, as well as of superfluous, callus. The imprisonment of a nerve-trunk may lead to severe neuralgia and paralysis. This is illustrated in the case of the musculospiral nerve in fractures of a shaft of the humerus. Functional disability of tendons and muscles may result from the relations which these bear to excessive and superfluous callus. Ulceration of the skin at the site of the injury from friction of bandages or clothing may also follow excessive callus.

Defective Formation of Callus; Pseudarthrosis.—Insufficiency of callus formation may be **relative** or **absolute.** The first named is due to local disturbing influences, while absolute defective formation of callus depends on general nutritive disturbances.

The causes of relatively defective callus formation are the following: (1) Excessive splintering or crushing of the bone. Here it is impossible for callus formation to occur until vascularization of the separate fragments has taken place. Hence delay, varying from four to twelve weeks, occurs in this

* While it has been asserted that the leukocytes form a new osteoblastic cell, this is probably not the correct view. The traumatic irritation reduces the bone to a condition analogous to that of young bone or identical with it. This is supported by the fact that, very frequently, cartilaginous tissue is found in the newly formed periosteal callus.

class of cases. It is somewhat rare for complete failure of union to occur. (2) Impossibility of complete coaptation of the fragments on account of the presence of a parallel unbroken bone, as in the case of the forearm and leg. Here each end may form both a periosteal ring of callus and a medullary dowel, but these fail to reach each other and unite. Displacement longitudinally, with separation of the fragments, will, in like manner, act as a cause of failure of union. (3) The interposition of muscle, tendinous structures, etc., as well as the occurrence of profuse hemorrhage between the fragments, also leads to failure of union. (4) Too early movements of the fragments, either through the restlessness of the patient or through the use of defective retention apparatus, may result in the formation of a synovial sac at the site of the fracture.

These are cases of **pseudarthrosis** in the proper sense, and are to be distinguished from cases in which a simple movable connection between the fragments has taken place.

Other local causes of pseudarthrosis and of movable connection between fragments of bone may occur without fracture, as, for instance, in loss of substance from necrosis following suppurative periostitis and osteomyelitis.

The general disturbances of nutrition which produce absolute failure of callus formation are included under the following: (1) **Rachitis.** This may simply retard the healing process, arrest it in its progress, or prevent it altogether. Antirachitic treatment is indicated. (2) **General syphilitic infection** may lead to the replacement of the reparative process by a syphilitic induration. Antisyphilitic treatment will be required before the normal processes of repair can proceed. (3) The presence of the **cancerous cachexia,** the condition of **carcinosis,** or the local occurrence of **malignant disease.** It is not always possible to determine whether or not the latter preceded and predisposed to the occurrence of the fracture or not. (4) **Scorbutus** is said to interfere with the formation of callus. (5) **Pregnancy,** by withdrawing the lime salts from the maternal circulation in the course of the formation of the fetal skeleton, renders the formation of callus more difficult. (6) **Chronic alcoholism** also interferes with the reparative process in fracture. (7) An **inhibition of the trophic nerve-fibers,** due to injuries of the trophic centers after spinal injuries, or disturbances of them, interferes with the local nutritive processes and thus brings about failure or retardation of union. (8) **Infection** and **excessive suppuration** at the site of fracture may prevent the completion of repair. (9) The occurrence of an **acute infectious fever,** such as typhoid, may also be mentioned as tending to prevent union.

The Course of Compound Fracture.—Provided an aseptic condition is maintained or an antiseptic state secured, compound fracture may undergo the process of repair in the same manner as a simple fracture. Not the severity of the injury itself but the absolute care which the surgeon bestows on the case and the relative susceptibility of the particular tissues involved will decide the question. The difficulties in securing an antiseptic condition are caused by the irregular shape and course of the wound which leads to the bone, as well as by the layers of loose connective tissue beneath the skin and between the muscular aponeurotic planes through which the wound passes, since these readily become the seat of extensive phlegmonous inflammation. The medullary structure, particularly in young persons, is peculiarly

prone to a high grade of phlegmonous inflammation (acute septic osteomyelitis), which, if the patient escapes with his life, will impair the usefulness of the limb through failure or insufficient union of the fragments. This is particularly liable to occur in comminuted fracture, the supply of blood being cut off from the smaller fragments by the inflammatory process, so that these undergo necrosis. These necrotic fragments may become imprisoned in the callus, forming the so-called sequestra. Callus may form at some distance from the fracture, where the inflammation is not of so high a grade. Small fragments which have been cut off from the blood-supply, provided the case pursues an aseptic course, may be inclosed by callus, and maintain their vitality.

Prognosis in Compound Fractures.—The prognosis of fractures complicated with wounds of the soft parts relates (1) to the danger to life; (2) to the integrity of the limb. Acute septic fever may destroy life in a comparatively short time, or a fatal result may follow chronic suppurative fever, with amyloid degeneration of the abdominal organs. The function of the limb may be temporarily or permanently impaired, or altogether destroyed. This may be due to influences affecting the bone itself or the surrounding parts. Of the former, may be mentioned the retardation of the consolidation of the fracture, the shortening of the limb in consequence of removal of sequestra or fragments at the time of injury, and the disturbances of growth before the full development of the skeleton. Suppurative inflammation of an adjacent articulation, and disturbances of functions of muscles and tendons in the neighborhood from acute and chronic inflammation of connective tissue planes, are instances of the latter. Molecular disintegration of the bony structure, or **caries,** and death of the bone *en masse*, or **necrosis,** may occur. The first of these results from inflammatory granular proliferation, the second from suppurative inflammation.

Treatment of Simple Fractures.—**Reposition.**—When displacement of the fragments is present, these must be "reduced," or reposition effected, **general anesthesia** being employed, if necessary, and measures taken to secure their retention as nearly as possible in the normal position. When no displacement is present, the latter alone will be necessary. The methods of reduction to be employed will vary according to the part injured and the character of the displacement. Mechanic aids to reduction are seldom, if ever, employed at the present time, anesthesia having made them unnecessary.

Extension and Counter-extension.—Force in the direction of the long axis of the limb, when peripherally applied, is called **extension**; the force which opposes this, or makes traction in the opposite or central direction, is called **counter-extension.** When muscular resistance is too great to permit reduction by the exercise of the surgeon's unaided strength, an anesthetic should be administered. The latter should likewise be employed if considerable pain attends the examination or the effort at reduction.

Impacted Fracture.—It may be to the patient's interest not to reduce a fracture, as, for instance, when immobilization has taken place through impaction of the fragments, as in fracture of the cervix femoris in an elderly patient, and there is reason to believe that permanent union through the formation of callus may follow, when otherwise this would be unlikely to occur. The so-called "green-stick" fracture, however, though held firmly by the inter-

denticulation of surfaces of the fragments, will require to be forcibly reduced in order that the normal axis of the limb may be restored.

Certain positions of the limb favor both reposition and retention. This is well illustrated in fractures of the clavicle and of the olecranon process of the ulna. Again, it may happen that the dislocated portion cannot be made to approach that which is still normal, in which case the latter must be made to accommodate itself to the former. Fracture of the upper third of the femur illustrates this. Reposition of fractured bony processes may be assisted by placing the joints in such a position as to relax the muscular structures attached to them.

When a reduction is indicated, it must be completely performed before a retention apparatus is applied. One must not expect splints by pressure to complete a reduction that has been incompletely performed.

Retention of the Fragments.—The fragments being restored to their normal position, it becomes necessary to apply such means as will overcome the tendency to redisplacement arising from involuntary muscular action, from voluntary movements on the part of the patient, and from the weight of the parts. The apparatus used in simple cases consists of **splints** and **retentive bandages.** These are applied to the whole or a portion of the limb, should always include, when possible, the next adjacent articulation and sufficient of the circumference of the limb to provide against movements of the broken parts on each other, and should be made to fit the various inequalities of the limb by systematic padding. Injurious constriction is to be guarded against on the one hand, and a too loose application of the splint on the other. As a result of constriction, gangrene from venous stasis, and loss of the limb may follow. Failure to guard against pressure on bony prominences sometimes leads to gangrenous ulceration at such points, which may extend to the periosteum and finally cause loss of bony substance. Too loose an application of the splint, on the other hand, while it does not lead to such disastrous consequences, gives rise to considerable pain, on account of the mobility of the fragments, and may be followed by the occurrence of deformity, if not by failure of union.

Retention of the fragments may be accomplished, under certain circumstances, by means of **permanent extension** (Buck). This may also be employed as a measure of reduction by tiring out the muscles, as in certain fractures of the thigh. The extending force is usually applied below the seat of fracture; in some instances, where it is necessary to overcome the action of muscles and there is not sufficient space below the fracture to apply the plaster extension strips, these may be applied above (Bardenheuer). Very oblique fracture of the tibia and fibula low down in the leg, in some cases, can be retained in no other manner. When extension is substituted for splints, or used in conjunction with them, provision must be made for a counter-extending force. The elevation of the foot of the bed or the use of a perineal band fulfils this indication in fractures of the lower extremity. Weights, graduated to the requirements of the case, with a friction roller or pulley, or elastic extension is used, as, for instance, in fracture of the femur. After reduction and the application of retentive apparatus, fluoroscopic inspection should be employed to verify the correctness of the apposition, and a skiagraph of the parts obtained for the future protection of the surgeon.

Treatment of Compound Fractures.—The treatment of a fracture complicated with exposure of the fragments to the atmospheric air, is that of a simple fracture, with the addition of aseptic or antiseptic treatment of the wound of communication. Thorough disinfection of the parts must precede the reduction. Some special difficulties to be met, in addition to those usually encountered in ordinary wounds, may be mentioned here.

A compound fracture may be infected through the medium of foreign bodies containing infectious material, or the source of infection may be the skin of the patient. On this account the latter must be at once thoroughly cleansed and shaved for a considerable distance around the wound. Most foreign bodies, even a bullet from a firearm, convey infection of greater or lesser degrees of harmfulness. The most harmful of foreign bodies, however, are the pieces of clothing, hair, straw, etc., which so frequently find their way into wounds of compound fractures. Digital exploration is advisable whenever possible and when the circumstances will permit thorough disinfection of the exploring finger, for only by this means can certain foreign bodies be distinguished from the contused soft parts, and the extent of splintering and the presence of detached fragments be determined. A sterilized finger-cot of thin rubber placed over the exploring finger is a wise aseptic precaution.

The removal of all loose bone splinters must be the next care. Though these do not necessarily become necrotic, still it is better to remove them whenever possible, in order to prevent the irritation arising from their presence, as well as to facilitate drainage and to get rid of the medullary substance which may cling to them, and which undergoes putrefactive changes very rapidly.

Large recess cavities in the depths of the wound serve as an indication for counter-openings for purposes of drainage. When these are made, they should be in a position where gravity will aid in affording exit to the wound secretions, and sufficient in number. It is a mistake to suppose that a single drain, in these cases, will serve the purpose. Every portion of the cavity, in all its recesses, must be thoroughly cleansed, irrigated with sterile saline solution, and either closed or packed with antiseptic gauze, according to the indications in each case.

The antiseptic dressings are to be applied in each case in such a manner as to permit the employment of the necessary splints or other retentive apparatus.

Very small punctures of the skin may, under certain circumstances, be simply cleansed as to surroundings and sealed with collodion, to which bismuth subiodid or iodoform has been added. A projecting point of bone should be removed *before reduction*, in order still further to lessen the chances of infection.

The After-treatment of Fractures.—The fact that the injured part is, in a manner, hidden away from the surgeon's gaze, and that the frequent disturbance of the seat of fracture is but a meddlesome procedure and not calculated to further the patient's best interests, taken in connection with the fact that certain important deviations from the normal course of repair may arise and without due care be overlooked, renders it important that the following precautionary measures should be taken:

1. Inspection of the peripheral parts (the fingers and toes), in order to

determine the presence of venous stasis, due to constriction from the bandage, or inflammatory swelling of the injured soft parts. This is evidenced by swelling and a bluish color. If pressure on a toe-nail or finger-nail produces a blanched appearance which is very slow in changing again to its former color, the dressings are to be removed immediately and reapplied more loosely.

2. The occurrence of pain is the rule during the first few days following the injury. This, however, is usually such as can be easily borne by the average patient. Should it, however, become excessive and progressively increase in severity, the dressings are to be removed and reapplied. In fractures of the leg special heed should be given to complaints of burning sensations or pain in the heel, since an intractable pressure sore frequently develops at this point.

3. The indications arising from the temperature should be carefully weighed. The resorptive, or Volkmann's aseptic fever, may exist during the first few days (see page 47) in simple fractures, having its origin in the substances which pass into the general circulation from the place of injury, such as disintegrated blood-corpuscles, the fibrin ferment of the blood, and medullary fat from the marrow of the injured bone. The aseptic fever of itself need give rise to no alarm. Should, however, a temperature of 102° to 103° F. be reached, it is an indication for an inspection of the parts and a renewal of the dressing. Inflammatory disturbances may, under these circumstances, be found to be present, and the fever prove to be a septic or pyemic fever, with its focus at the point of injury.

The **ambulatory treatment** of fracture of the lower extremity, enabling the patient to walk about with no other aid than that of the special splint applied, is sometimes attempted, with the expectation that the patient's general health will be conserved, the local processes of repair stimulated, and more rapid and firmer union secured. The method is not one of general applicability.

In compound fractures frequent inspection of the parts will be made necessary by the occurrence of discharge or elevation of temperature, as above described. Simple fractures with but slight or easily corrected displacement may be allowed to remain uninspected for a period averaging about four weeks from the time of injury, unless the dressings loosen and require removal on this account. In very oblique fractures it is wise to remove the dressings at the end of the second or during the third week, in order to be certain that the displacement has not recurred.

Fractures in the neighborhood of joints in which there is practically no tendency to displacement, so that manipulation may be made, should be massaged daily from the commencement. In fact, any fracture of the extremities may be treated in this manner with advantage where the conditions present will permit it. In all cases, where practicable, the patient should not be confined to bed any longer than is necessary, but should be allowed to move about at the earliest possible moment.

Treatment of the Functional Disturbances Following Fractures.—The disturbances of function which follow union of fractures consist in (1) edematous swellings due to circulatory changes in the parts; (2) the presence of the residuum of the extravasation; (3) adhesions in and about muscular and tendinous structures; (4) atrophy of muscles from nonuse; (5) interfer-

ence with the movements of neighboring joints from excessive callus or inflammatory exudate; (6) undue shortening of the limb; (7) vicious callus.

The first four conditions named are benefited by massage, elastic bandages, passive movements, warm baths, electricity, etc.

Interference with the movements of joints which cannot be remedied by passive motion will be described later (see page 161). Undue shortening of the limb is to be remedied by an extra thickness of sole on the shoe worn on the injured side. When partial union or delayed union is encountered, it is often well to use various orthopedic braces to protect the limb, to shorten the period of confinement, and to permit an improvement in the general health, which in turn will often promote more complete repair in the fracture. Ununited fractures are to be treated on the lines laid down in the section on operations on bones. Amputation for these complications is seldom resorted to at the present day. In case of joint disturbances of an intractable nature, particularly those of the shoulder-joint, resection may become necessary to restore the function of the limb.

Osteoclasis, or **refracture,** may be necessitated by undue deformity, and **resection of the callus** in vicious union in which the function of a neighboring bone is interfered with, as, for instance, the radius and ulna in their functions of pronation and supination.

GUNSHOT INJURIES OF THE LONG BONES

The destructive effects of the old and new projectiles are alike severe, and in certain localities, as, for instance, the femur, the injury inflicted in some instances by the modern bullet is scarcely exceeded by that produced by the old spheric missile of former times.

Owing to the great resistance which compact bone offers to the impact of projectiles, lesions of the diaphyses in gunshot injuries are much more extensive than in the case of the epiphyses (see Gunshot Injuries of the Joints, page 147). In the case of the jacketed bullet of high velocity and at short range the bone is finely comminuted, and the debris from it is driven along the wound canal. Bony fragments are torn loose from the periosteum and increase the damage to the soft parts, the bone being fissured in its long axis in both directions. The wound of exit in the bone is much larger than that of entrance, showing the effect of resistance in causing an explosive reciprocal back-action on the projectile through which a part of its intrinsic power is converted into deformation (R e g e r). At longer range the missile is deprived of a part of its velocity before striking, as a result of which the perforating and explosive back-action effects are lessened and the shattering effect is increased. The fragments are larger and remain attached to the periosteum, and the fissures are longer. Under favorable circumstances, *e. g.,* where the mantle escapes injury, the resistance to the passage of the missile is reduced to the minimum, the tendency to tissue explosion is lessened, and complete perforation of the bone, together with comparatively slight comminution and fissuring, is observed. In other cases fracture without displacement occurs. Finally, under the influence of a high velocity the missile may strike a concave surface of bone, and, instead of glancing off, cut a clean groove (guttering of bone).

INFLAMMATORY PROCESSES IN BONE

These are primarily situated in the periosteum or the medullary cavity, while an osteitis proper is an inflammatory condition of the vascular canals of the bone, with secondary changes in the bone itself resulting from interference with its nutrition.

Periostitis.—Inflammatory processes arising in the periosteum may be confined to this layer or spread through the vascular channels to the marrow, thus involving the whole bone. There are four varieties of periostitis: fibrous, ossifying, serous, and suppurative.

Fibrous periostitis is a connective-tissue inflammation resulting in a thickening of the membrane. It arises from traumatism, from continued irritation, from mild types of bacterial infection either from contiguous inflammation of the soft parts or through the circulation. It is a chronic process, and if the cause is long continued there is a development of new bone substance among the connective-tissue cells, so that this becomes an **ossifying periostitis.** This is a reparative process, and is seen in the union of fractures.

Serous periostitis, or the osteitis albuminosa of Ollier, is of rare occurrence. By some authorities it is regarded as a distinct variety, by others as a less intense variety of the ordinary suppurative type. While a serous, synovial fluid is found beneath the periosteum, tuberculous or pus germs have been demonstrated in the fluid in small quantities. The cases occur in childhood or in early youth, are subacute in type, and, if lasting many weeks, show plainly that the primary lesion was an osteomyelitis.

Suppurative periostitis as a primary lesion does not occur after an open septic wound or as a metastatic septic process, yet, as a rule, it is secondary to an underlying suppurative inflammation of the medulla. This fact is important to bear in mind, else the treatment instituted will not be radical enough to eradicate the source of the septic process.

The inflammations starting in the medullary cavity are of two varieties: the suppurative, usually acute, but often subsiding into a chronic stage after drainage that is inadequate, whether it be spontaneous or operative, and the granulating type, usually chronic and due to tuberculosis or syphilis. As a result of these inflammatory processes, whether starting in the periosteum or medulla, certain changes may occur in the bone itself. These consist of a molecular disintegration of the bony structure, or **caries,** and death of the bone *en masse,* or **necrosis.** The first of these results from inflammatory granular proliferation, the second from suppurative inflammation. These terms, **caries** and **necrosis,** were formerly used to signify the disease of the bone itself; it is now a recognized fact that they are simply conditions arising as a result of the inflammatory state, caries from a **myelitis granulosa,** necrosis from a **myelitis** and a **suppurative periostitis.**

Hyperplastic Inflammation.—This is observed in cases of **excessive formation of callus,** and in the course of **arthritis deformans.**

Tuberculous Necrosis.—In addition to the caries resulting from granular inflammation, the bone may die *en masse.* This differs from the acute necrosis of suppurative inflammation in several ways. The mass is smaller, is usually found at the epiphysis of the long bones or in short bones, and consists of cancellous tissue. In shape it often resembles a wedge, the base being directed toward the joint. It results from the obstruction of a vessel by the

granular caries, and the death of all bone nourished by that vessel. This form is described by König under the name of "tubercular infarct." Separation of the sequestra takes place much more slowly than in the case of suppurative inflammation.

Inflammation of the Medullary Tissues; Acute Suppurative Osteomyelitis.—This follows two types: (1) acute epiphysitis, usually in children; (2) acute osteomyelitis of the shaft, usually from a septic wound, as compound fracture, or through the circulation.

1. **Acute epiphysitis** attacks the nearest layers of medullary tissue, which are situated next to the epiphysial cartilage. This is in part due to the fact that here the microorganisms from the blood find a soil best suited to their development. The vessels in these localities assume the shape of broad hollow spaces or lacunae, in which retardation of the blood-current occurs, this of itself favoring the arrest and lodgment of the cocci therein. In addition, the physiologic activity is greatest at this point, and hence a predisposition to inflammatory processes exists.

It is more than probable that the infectious agent in these cases is **Staphylococcus pyogenes aureus** (see page 26), as shown by the observations of Lücke and Recklinghausen, and that this finds its way into the circulation through the mucous membrane of the respiratory passages and digestive tract, inflammatory disturbances of these structures frequently preceding the onset of the disease in question. For example, follicular tonsillitis is often the primary source of infection (Kocher). That the disease does not directly invade the joint structure is due to the absence of vascularity of the epiphysial cartilages. It is readily propagated in the direction of the periosteum, along the blood-vessels, at which point it meets with the subperiosteal connective tissue. The disease thereafter pursues a course partly within the medullary tissue and cancellous structure, and, proceeding through the bone by way of the vascular canal, partly in the subperiosteal connective tissue, or intima of the periosteum. The suppurative process now makes its way through the latter, and an abscess invading the soft parts surrounding the bone follows.

Constitutional disturbances more or less pronounced accompany the progress of the disease. In the hyperacute type the temperature may reach 105° F., or even higher. This may be preceded by a chill or a succession of rigors. Delirium or coma may supervene and the patient perish from the violence of the general symptoms before the local conditions are sufficiently distinctive to attract the attention of the medical attendant, particularly in the case of very young children, from whom it is difficult to obtain a satisfactory history as to localized pains, etc. Again, the disease may run a prolonged course, simulating typhoid fever. Pneumonia, probably of metastatic origin, is a not infrequent complication.

The local symptoms, except the occurrence of pain, are not distinctive in the beginning. The occurrence of localized edema is the first objective sign of the source of the disturbance, this preceding the appearance of the abscess. After the opening of the latter, whether artificially or spontaneously, the disturbances of nutrition in the bone become apparent. Necrosis is discovered to exist, this being either localized or affecting the entire bone, according to the extent of the necrotic process. The separated portions of bone are called

sequestra, and these are called **total, cortical,** or **central,** these terms corresponding respectively to the extent and the location of the separated portions. The separation of the periosteum by the invasion of pus beneath its surface is not necessarily followed by the destruction of its osteogenetic properties. In this case a new formation of bone occurs, and the latter, imprisoning a sequestrum, is called the **involucrum.** Here and there on the surface of the periosteum the bone-forming property of the latter is destroyed, or the periosteum has given way under the pressure from within. Here failure of new formation of bone occurs, and openings lead through the periosteum and involucrum to the sequestrum within the latter. These openings are known as **cloacae.** The abscess cavity in the soft parts contracts, after escape of its contents, and the channel of communication with the diseased bone beneath is called a **fistula.**

While the inflammatory process does not invade the neighboring joints directly by vascular communication, on account of the protection which the epiphysial cartilage affords, yet the separation of the latter, together with that of the epiphysis from the diaphysis, by the suppurative process, leads to the invasion of the joint, and a suppurative arthritis results.

2. The **acute osteomyelitis** secondary to compound fractures is less common since the antiseptic treatment of such cases has been used. The lesion is the same as has just been described. The symptoms are those of septic infection; death may result from septicemia.

Treatment.—Treatment directed to the arrest of the disease by means of free incisions can scarcely affect the medullary infection, except possibly by the effect produced by antiseptic agents conveyed to the parts from the periosteal involvement. When free incision fails to reveal the presence of a sufficient amount of disease to account for the symptoms, the chiseling away of a portion of the bone, in order to reach the central point of infection, is demanded. After large abscess cavities have formed in the soft parts, free incision and antiseptic treatment of their interiors fulfil, for the time being, all the indications. Attempts to resect such portions of bone as have been denuded by the separation of the periosteum have not, thus far, been followed by very encouraging results. As soon as the diagnosis of an acute osteomyelitis is made, even within the first day or two of the disease, it is wise not only to incise the periosteum, but, by chisel or trephine, to open the medullary cavity. Though pus has not yet formed, the acute sepsis is relieved, and not only is life saved in the more severe cases, but even when the symptoms are less alarming, the local process is arrested and less bone dies. Thus the extensive destruction often observed in the late cases is avoided. Though a second operation for removal of sequestra or caries may be indicated in two or three months, this is less extensive than if the primary drainage of the medullary cavity had been omitted.

The separation of portions of bone is an indication for immediate operative interference. Should the sequestra be sufficiently small to be removed through the fistulous channels, **extraction** may suffice. If not, the operation of **sequestrotomy** must be resorted to (see page 369). The granulating process sometimes crowds a sequestrum to the surface; quite large cortical sequestra are thus spontaneously expelled. The fact that sequestra are sometimes dissolved by the granulations led to the attempt to imitate the process,

and lactic acid was employed for this purpose. Later, the application of pepsin and hydrochloric acid was suggested (Morris). The researches of Tillmanns seem to indicate that the carbonic acid of the blood serves to dissolve, to some extent, the necrotic bony tissue. The best of the means employed for this purpose, however, are inferior to operative interference.

Myelitis Granulosa.—Granulating inflammation of the medullary tissue of bone is due, in the great majority of cases, to the infection of either tuberculosis or syphilis. It may be either a primary or a secondary tuberculous manifestation. The tubercle bacillus does not choose necessarily the young layers of the medullary tissue, as do the infectious agents of suppurative osteomyelitis, but selects any bony structure consisting of a relatively large amount of medullary tissue, such as the bodies of the vertebra, the bones of the tarsus, carpus, etc. Irritation of the medullary structure follows the presence of the bacillus, and a slow granulating process is inaugurated; absorption of the cancelli follows, the granular foci coalesce and the cortical layer is destroyed to a greater or lesser extent. Suppuration finally occurs in the foci of deposit, which finds its way to the surface through destruction of the cortical layer, and an abscess makes its appearance. This abscess differs from the acute form characteristic of suppurative osteomyelitis in being very slow in its course, distinctly circumscribed, and in having no tendency to involve surrounding parts (cold abscess). These abscesses occasionally become infected with the pus organisms and run an acute course. In case the bone is attacked in the neighborhood of a joint and perforation takes place in the direction of the latter, a **synovitis hyperplastica granulosa** occurs. A granulating **tenosynovitis** may likewise occur from involvement of the tendinous sheath. The pus usually makes its way to the surface sooner or later, and is discharged either by ulcerative action or through an incision; it may, however, remain at its original point of formation, thus constituting a **bone abscess.** These bone abscesses are prone to occur near the articular extremity of a bone, particularly near the head of the tibia and at the olecranon process of the ulna. Sequestra are rather infrequently formed; when these do occur, they are insignificant compared with those present in suppurative osteomyelitis. Fistulous openings may communicate with the broken-down granular focus, and the granulations themselves, when exposed to view, are found to be of a grayish-yellow color; they have no special tendency to cicatrization. Microscopic examination shows numerous groups of microorganisms and sometimes real tubercle as well.

The course of the disease differs in several important particulars from that of the disease last described. The febrile symptoms are less marked. At night the elevation of temperature may not reach more than a single degree above the normal. The destructive process in the bone is always in the direction of caries rather than in that of necrosis. While suppurative osteomyelitis may prove a dangerous affection in the beginning, particularly in children, the disease under consideration presents few alarming features in its incipiency. This is compensated for, however, by the serious after-course of the affection. Both may be complicated by amyloid degeneration of the abdominal organs, but, in the granulating form, there exists the special danger of **general tuberculosis.**

The tuberculous deposit which may occur either as a circumscribed nodular product, or as tuberculous infiltration in cases of myelitis granulosa, is converted into yellow tubercle by the process known as **caseation.** This

process is analogous to fatty degeneration but not identical with it. It is the result of the presence of the bacillus of tuberculosis or its ptomains, and is preceded by coagulation necrosis. Softening occurs coincidentally; a number of these cheesy foci may become confluent and form a large caseous center. The bacillus cannot be found in these, having perished from starvation, but experimental inoculations show the cheesy material to be infectious. This is due to the presence of the spores, which remain in an active condition.

Treatment.—The use of remedies directed against the tubercle bacillus in the treatment of the diseased focus has been attempted. Among the first of these employed may be mentioned carbolic acid in solution (from 3 to 5 per cent), suggested by Hueter, and Landerer's arsenious acid injections. More recently encouraging results have been obtained by the use of a 10 per cent emulsion of iodoform in glycerin or balsam of Peru (Senn), and a 5 per cent alkaline emulsion of cinnamic acid (Landerer). In the case of iodoform, which has given good results, it is not definitely known whether the curative effects are due to the iodoform as such or to the formic acid, which, it is claimed, is one of the products of the decomposition of this agent in the tissues. The injections may be made every two weeks, and from one-half to one ounce of the emulsion injected at each séance.

Ignipuncture.—Deep cauterizations were employed (Richet, 1870) by means of a narrow platinum pointed cautery-iron. Kocher, independently of Richet, employed the method, but considered its use indicated particularly in recent cases. The Paquelin cautery is a better instrument for the purpose. The operation should be performed under strict aseptic precautions. The compact bone is usually softened sufficiently to permit the point to penetrate to the tuberculous focus. The tunnel or channel thus made should be dressed with iodoform.

Chiseling and Évidement.—These may be employed in all stages of the disease. They, together with typic resection or amputation, constitute the radical treatment of the disease. In these tuberculous lesions special attention should also be paid to general medication, diet, and hygiene, as important adjuncts to the surgical procedures indicated.

Syphilitic Affections of Bone.—These belong to the so-called tertiary stage of the disease. With our present knowledge of the necessity for prolonged treatment in the earlier stages of syphilis, they are somewhat less common than formerly.

Syphilitic Osteomyelitis.—Granular inflammation of the medullary tissue as a result of syphilis is comparatively rare. It sometimes attacks the phalanges of the fingers and toes, particularly in the congenital form of the disease. In the rare cases in which syphilitic granulating inflammation of the marrow of long bones occurs, the infected foci are present in considerable numbers. The course of this disease is somewhat similar to that pursued when the disease is due to tuberculous infection. The bone is usually considerably condensed in the neighborhood of the foci, and the sequestra are, as a rule, inclosed by solid-walled involucra.

Syphilitic Periostitis.—This commences as a flattened swelling or **gumma.** The favorite sites are the anterior border of the tibia, the ulna, radius, clavicle, and the frontal, parietal, and occipital bones. These being the most exposed

to injury, it would seem as if traumatism acted as an exciting cause. The periosteum is invaded by soft granulating tissue, which forms the flattened swellings or gummas; the membrane becomes thickened, the nutrition of the bone is interfered with, and destruction of the latter follows. Under anti-syphilitic treatment these swellings frequently disappear, leaving either a bony defect, or an elevation the result of an ossifying periostitis, at the site of the former gumma. Suppuration and ulceration of the overlying skin, with necrosis, is the rule in untreated cases. The skull is specially predisposed to the multiple form of the affection.

Diagnosis.—When the history of a primary sore, or that relating to the secondary manifestation of the disease, can be obtained, the diagnosis is not difficult. In the absence of these, syphilis of bone must be differentiated from tuberculous disease. In the skull, and the fingers and toes, tuberculous bone disease is not so likely to be multiple as syphilis of bone. In the latter the destructive processes are in the direction of necrosis rather than in that of caries. The microscope may be made available in the differential diagnosis.

Treatment.—The therapeutic indications, as far as internal medication is concerned, are those of syphilis. The local treatment consists in free incision, thorough scraping and disinfecting by means of a 1:1000 solution of chlorid of zinc. Necrotic portions of bone must be removed, by chiseling, if necessary.

Actinomycosis.—The actinomyces, the specific organism of this disease, is described on page 209. It attacks the bones and adjacent parts, as well as other tissues of the body. The lower animals (oxen, horses, swine, etc.) are affected by it as well. A chronic soft granulating inflammation occurs at the site of the infection, which gradually changes to a hard swelling. The exterior of this is formed of calluslike connective tissue, but the interior is made up partly of small suppurative foci and partly of suppurative canals; in the semiliquid contents of these canals, peculiar bodies having a diameter of 2 mm., either colorless and diaphanous, or opaque and white, yellow, brown, or green, and visible to the naked eye, are found floating.

In all probability the fungus finds its way into the human body with the food. It is sometimes found in carious teeth and in the crypts of the tonsils. The most frequently selected site of actinomycotic inflammation is the lower jaw. Hard and immovable swellings occur on the bone, differing from those of common periostitis by their slower growth and peculiar doughy character. Suppuration with discharge of pus, usually into the cavity of the mouth, follows. The actinomyces may be demonstrated in the pus. In other cases the entire submaxillary bone may become invaded, with involvement of the neighboring soft parts in the doughy swelling, without well-defined boundaries. Fistulous openings lead to the diseased bone. The infection travels along the connective-tissue spaces, hence the lymphatic glandular structures are not involved. In this manner it may reach the anterior portion of the vertebral column in the cervical region. The suppurative process is not an essential product of the actinomycotic inflammation, but rather the result of the invasion of suppurative cocci.

Diagnosis.—This can be made positively only by the recognition of the before-mentioned bodies by aid of a microscopic examination. In suspicious cases an exploratory incision is justified.

Prognosis.—In the beginning of accessible foci, free incision and energetic treatment may arrest the disease. Once the connective tissue is invaded, however, the case is almost hopeless, the patient succumbing to the slowly progressive suppurative process, with its accompanying amyloid degeneration of the abdominal organs.

Treatment.—Early incision, free curetting with Volkmann's sharp spoon, and subsequent thorough disinfection of all the parts by means of a 10 per cent solution of chlorid of zinc, constitute the only trustworthy means of relief at our command. The condensed connective tissue which forms the outer or shell portion of the nodules should be dissected away, as it sometimes contains the infective agent, and, if permitted to remain, may lead to recurrences.

Rachitis is a constitutional disease, but the important lesions and symptoms occur in the bones. It is essentially a disease of malnutrition. This may result from poor assimilation and intestinal disorders in the children of the rich, but more frequently from improper food and hygiene in the children of the poor. It usually begins in infancy. It is very common in Europe, less so in America. It consists of a defective deposit of lime salts and a hyperplastic proliferation of the cartilaginous and periosteal structures at the extremities of growing bones. The earlier symptoms are those of intestinal catarrh, irregular dentition, and a delay in the closure of the fontanels with a thinning of the cranial bones, or **craniotabes.** At this stage perspiration about the neck is well marked.

Diagnosis.—The special characteristics of the disease for diagnostic purposes are the peculiar enlargements of the ends of the bones. These may be fusiform or ringlike. At the anterior extremities of the ribs these enlargements form the so-called "rachitic rosary." A peculiar curve extending from the level of the ensiform cartilage toward the axilla and corresponding to the insertion of the diaphragm (Harrison's groove) is diagnostic. The lower ends of the radius and fibula are specially affected, forming a transverse swelling at these points. In the case of the sutures of the skull, these appear as flat prominences.

Of the vast number of conditions resulting from this disease of the general skeleton, the most important, from the surgical standpoint, are the subperiosteal fractures, the retardation of callus formation, and certain deformities at the joints and in the shafts of long bones. These will be considered under their appropriate heads.

General Treatment.—The general treatment of rachitis consists in supplying the patient with wholesome food and pure air. The diet should consist mainly of milk, eggs, and meat. The phosphate and carbonate of lime and ferruginous tonics are to be prescribed. The administration of pure phosphorus and cod-liver oil is also of service. The tendency to intestinal catarrh should be borne in mind.

Osteomalacia.—As distinguished from rachitis, this disease is characterized by a softening of the fully developed bone. It is endemic in certain regions (the Rhine and its tributaries, Alsace, Flanders, and Westphalia). It is almost exclusively limited to the female sex during the period of pregnancy. Its occurrence is favored by unwholesome food, damp places of residence, and privations of different kinds.

In the puerperal condition the pelvic bones are primarily involved, and

the disease is frequently restricted to these. The lower and upper extremities and vertebral column may become affected, particularly under the influences of repeated pregnancies. The nonpuerperal form originates generally in the bodies of the vertebra, extending to the bones of the upper extremity, skull, chest walls, pelvis, and lower extremities. The disease consists essentially of a softening of the bone by a decalcifying process, the primary origin of which has not been discovered.

The bones become bent and otherwise distorted, and fractures, either partial or complete, occur. The carrying of burdens by pregnant women afflicted with the disease favors distortions of the pelvic bones. Cesarean section is frequently necessitated by the presence of the latter.

Diagnosis.—In the early stages of the disease the symptoms are not sufficiently distinct to suggest its presence. The peculiar rending pains are usually attributed to rheumatic affections of the bones and muscles. The characteristic deformities alone denote the true character of the affection.

Prognosis.—The prognosis is, as a rule, very unfavorable. Recovery rarely takes place.

Treatment.—There is practically no treatment other than that relating to favorable hygienic influences. Alterative tonics may be prescribed, and salt baths, together with nutritious food. Women in the child-bearing age should be warned of the dangers which attend pregnancy occurring in the course of this disease.

Osteopsathyrosis or Rarefying Osteitis.—In this affection an abnormal brittleness of the bone exists. Those layers of the cortical portion adjacent to the medullary canal, as well as the cancelli, disappear, and the medullary lacunae become enlarged and filled with yellow fatty marrow (lipomatosis). It is the common form of senile atrophy of bone, and that which produces many of the fractures occurring in old age, as well as those of **tabes** and **paralysis** (Charcot), with an insufficient or trifling traumatism. The striking absence of pain following these fractures will at once suggest their cause. This **osteopsathyrosis tabetica** occurs only after the disease of the spinal cord is far advanced. The failure of the paralyzed muscles to support properly the shafts of the bones also favors the occurrence of fracture.

Tabetic fractures may unite, as other fractures, by proper treatment. Even large deposits of callus may be favored by movements in patients insensible to pain.

Sarcoma of Bone.—This occurs as periosteal sarcoma and central sarcoma.

Periosteal sarcomas occur comparatively early in life, and their occurrence is not infrequently referred to some preceding injury. They affect by preference the articular extremities. When springing from the shaft, the growth may be restricted to a portion of the circumference, or form a fusiform swelling enveloping the entire bone. The bone itself, however, becomes ultimately affected through the Haversian canals. The joints are rarely involved.

The cellular elements of periosteal sarcomas may be either round or spindle-shaped. These growths are especially prone to calcification and ossification.

Central sarcomas occur in individuals from ten to forty years of age, and are more frequently observed near the articular extremities of the long bones; exceptionally they may arise from the middle of the shaft. In the former

situation they are spindle-celled, in the latter round-celled. The long bones of the lower extremity are affected by preference. Joint cavities are rarely invaded, and adjoining lymphatic glands are only exceptionally involved. The cells may advance along the Haversian canals, and a tumor form on the external surface of the bone beneath the periosteum. Enlargement of the bone also takes place from an encroachment of the growth on its bony walls, which finally give way, and there results as one of the clinical phenomena a strong rhythmic pulsation and bruit.

THE JOINTS

Contusions of the Joints.—Joints in which the capsule is in close relation with the bony surfaces on the one side and the integument on the other (the knee-joint, phalangeal joints in flexion, etc.) may be the site of severe contusion, or even a tearing of the capsule. **Hemarthrosis** is a not infrequent consequence of contusion of a joint. The hemorrhage into the joint may arise from an injured vessel in the capsule or its immediately overlying structures (articular arteries in case of the knee-joint, etc.), or there may be a tearing off (fracture) of a portion of the bone inclosed by the capsule or attached to it, the hemorrhage resulting from the vessels in the bone.

Symptoms.—A swollen condition of the joint ensues on the occurrence of the accident, sometimes accompanied by subcutaneous and subfascial hemorrhage. When no subcutaneous hemorrhage complicates a hemarthrosis, the joint is not discolored. If sufficient blood has been effused into the joint, fluctuation may be present. The interposition of thick soft parts, or extreme tension due to a large amount of blood, may mask this symptom. The fluctuation felt at first gives place to a gelatinous or even a harder resistance after a short time, when the blood coagulates. The movements of the joint are restricted when the intra-articular tension is very great. The limb sometimes assumes a position that relaxes the joint capsule. Crowding the fluid into one or another part of the joint, as, for instance, into the space beneath the quadriceps extensor by extending the limb and applying an elastic bandage from below, or by means of the fingers, in the case of the knee-joint will reveal fluctuation in doubtful cases. When flexion is made, the fluid disappears from the region, the bandage being removed.

Normal Course.—The blood, if it remains in a fluid state, may become resorbed as such. Or, separation of the fibrin having taken place, the fluid portion may be resorbed. It has been shown that even pigment granules may be resorbed in this manner. Their presence has been demonstrated in the next adjacent lymphatic glands. Under these circumstances a peculiar crepitation (snowball crackling) is felt, due to the presence of the remaining fibrin. Organization of the fibrinous clots does not, in all probability, take place, but proliferation of the synovial membrane on the basis of these may occur which may finally replace them and form adhesions within the joint cavity. Suppuration is rare, except in cases of open wounds. When **hydrarthrosis** follows hemarthrosis, this is probably due to the accompanying synovitis. Differentiation of hydrarthrosis and hemarthrosis is usually made by the history; in cases of doubt, exploratory puncture will clear up the diagnosis.

The Treatment of Injuries of the Joints.—If these are uncomplicated by

an external wound, even though they may be very severe in character, simple rest may suffice for complete restoration of function. This is well illustrated in some forms of dislocation. Hemorrhage within the joint requires no treatment, in many instances, beyond the simple application of an ice-bag and splint. The synovial fluid, however, frequently persists to an extent requiring the use of elastic compression (Martin's elastic bandage); this failing, tapping by means of a trocar, evacuation of the fluid, and irrigation of the joint by an antiseptic fluid are indicated. Suppuration, as indicated by urgent pains and the occurrence of a high temperature, should be met by incision of the joint, antiseptic irrigation, and drainage.

Wounds of Joints.—The dangerous character of these demands the exercise of the most rigid aseptic and antiseptic precautions. The irregular shape of joint cavities renders this particularly difficult. Drainage will be needed, as a rule, in cases in which infection is suspected to have occurred.

When the cavity fails to maintain an aseptic condition, it may be necessary to resect a portion of the joint surfaces, in order to gain access to it. This will usually be required in case of wound of the joint complicated by a fracture. The question of **total** or **partial resection** will depend on the indications to be fulfilled. An improved functional result is frequently obtained by this method of treatment, particularly in cases of suppuration due to traumatism.

In severe cases of injury of a joint, primary or secondary **amputation** may be demanded. When the joint alone is involved, however, resection will frequently suffice. Injuries of large nerve-trunks and vessels, in addition to the wound of the joint, indicate primary amputation. In suppuration of joints, whether resection or amputation is resorted to, any phlegmonous processes that have occurred along muscles and tendinous sheaths must be followed up by free incisions, antiseptic irrigations, and efficient drainage.

Gunshot Wounds of the Joints.—In former times gunshot wounds of the larger joints, such as the knee-joint and the hip-joint, ranked among the most serious of this class of injuries. At the present day, owing to the aseptic care which all wounds receive, and the use of the armored or protected projectile, the importance of these lesions has been greatly reduced. The destructive effects of the impact of the modern high-velocity and small-caliber missile as it strikes the spongy structure of the articular extremities of long bones without deviation from its normal course or change in its long axis, even at the shorter ranges, are greatly minimized, and the resulting damage is very limited. The wound inflicted under these circumstances is usually a small, clean-cut perforation which offers relatively slight opportunity for infection. In case of a ricochet shot with change in the angle of incidence from that of a right angle (cross-hits), particularly where deformation of the bullet takes place (see page 166), more or less comminution of the bone may occur and a correspondingly severe injury of the joint result. In the case of the old-fashioned large and unprotected ball the resistance met is sufficient to produce changes in the shape of the missile, and far more extensive lesions. The larger wounds inflicted invite the entrance of infection and the extensive disorganization of the tissues offers favorable opportunity for its propagation and dissemination. In addition, the low velocity often leads to the lodgment of the ball.

DISLOCATION

A more or less permanent disturbance of the relations of joint surfaces to each other constitutes a dislocation. This may occur, as in fracture, from either direct or indirect violence. Physiologic resistance to the movements of joints beyond the normal limit resides in the ligamentous structures. In dislocation these are necessarily overstretched, and torn to a greater or lesser extent.

Primary and Secondary Distortion.—An exaggeration of a normal movement, as, for instance, when hyperextension at the elbow forces the olecranon into the intercondyloid fossa and removes the bones of the forearm from their relation to the lower end of the humerus, constitutes what is known as primary distortion. Whether or not a true dislocation occurs subsequently to this depends on the further forcible movements to which the joint is subjected, the character of the dislocation depending on the direction of these movements. The action of the attached muscles, together with the position of still untorn ligamentous bands, constitutes one factor in determining the direction of the dislocation. Another factor depends on the position in which the limb happens to be placed when the primary distortion occurs. A third relates to the direction of the impinging force. With the exception of the first named, it is frequently difficult to estimate, in individual instances, the prominence to be given to each of these factors. When the joint surfaces are entirely removed from contact with each other, a complete dislocation or **luxation** occurs; when these are still in partial contact, a **subluxation** is said to take place.

Prognosis.—Simple dislocations, properly reduced, are not, generally speaking, important injuries. Repair of the torn capsule and of other ligamentous structures takes place readily. The hemorrhage, as a rule, is not alarming. In the after-treatment, however, an untoward condition of laxity or flabbiness of the joint may arise from too early movements, which disturb the proper repair of the torn capsule and lead to a broad "splicing" of the rent, rather than to immediate union of the torn edges. Recurrence of the dislocation may then occur (see Habitual Dislocations, page 150).

Symptoms of Dislocation.—Inspection.—Changes in the contour and size of the extremity are at once apparent. Shortening, except in exceptional instances (obturator dislocations of the femur), is present. An enforced position of the limb is also observed. Comparison with the healthy side should always be made. In recent dislocations some ecchymotic discoloration of the parts is present. Swelling may be a prominent feature, occasionally to the extent of masking the symptoms referable to changes in contour and size.

Palpation.—The evidence derived from a study of the contour of the part by inspection is augmented by palpating with the fingers. The relations to each other of the bony prominences adjacent to the joint are thus made out. In order to assist in the diagnosis in case of severe and recent hemorrhage the finger may be made use of to force the blood away from the injured locality.

Mensuration.—A tape-measure or other measure is necessary to determine the lengthening or the shortening of the entire extremity, as well as the altered relations of bony prominences to each other.

Dislocation Combined with Fracture.—Dislocation and fracture may be combined. This may occur by the breaking off of a bony projection which

bars the progress of the dislocated bone (fracture of the coronoid in forward dislocation of the humerus at the elbow-joint); by the tearing away of the bony insertion of an overstretched ligamentous band, the bone giving way before the ligament (Pott's fracture); and, finally, by the subsequent fracture of the previously dislocated bone by the same force. In these cases the symptoms of fracture are added to those of dislocation. In comparing dislocations with fractures it is to be observed that less functional disturbance results from the former than from the latter. The position of the bone permits limited voluntary movements of the limb. In fracture, on the contrary, the loss of support of muscular attachment and the occurrence of excessive pain produce complete disability. On the other hand, however, under anesthesia the utmost freedom of motion is observed in fracture, while this is comparatively very limited in dislocation. Except in instances in which a dislocated bone makes direct pressure on a nerve-trunk, the pain in fracture is greater than that in dislocation. Difficulties in differentiating fracture and dislocation may occur when the former exists in close relation to a joint. This is particularly true of injuries in the neighborhood of the shoulder-joint and hip-joint.

Treatment of Dislocations.—The immediate restoration of the normal relations of the joint surfaces to each other, except in cases complicated by fracture close to the joint, is imperative in all dislocations. Since the introduction of anesthesia, this may be accomplished without the aid of special apparatus, which in former times was necessary to overcome muscular resistance. In planning an effort at reduction of a dislocation the attempt should be made to follow in a reverse order the movements which led to the dislocation. The so-called secondary movement occurring during the luxation is first to be compensated for by a movement in the opposite direction, after which the primary distortion is to be rectified. These constitute the so-called anatomic methods of reduction.

After reduction the enforcement of rest sufficient to permit union of the torn ligamentous structures will be necessary. The application of an ice-bag to lessen the pain and swelling will frequently be of service. In simple dislocation a period of fourteen days should elapse before even slight movements are permitted, retentive bandages being applied in the meanwhile. In dislocations complicated with fracture, not less than four weeks' immobilization will suffice. In these cases too early movements endanger the future mobility of the limb more than prolonged fixation in one position. While complicated dislocations are quite likely to lead to some impairment of function, simple dislocations usually terminate, when properly treated, in complete restoration of former physiologic conditions.

Compound Dislocations.—Compound dislocations are much more rarely observed than compound fractures. The blunt articular extremities of the bones do not favor perforation of the overlying soft parts to the same extent as do the ends of the fragments in fracture. Exception to this may be noted in the case of the olecranon. Compound dislocations usually result from machinery accidents or direct crushing force. The choice of treatment lies between primary resection and reposition with antiseptic treatment. When the danger of infection is great, the first course is the safer. Secondary resection may be required, either on account of septic conditions or for the purpose of improving the functional result, as in the case of the shoulder-joint.

Ancient Dislocations.—A failure on the part of the surgeon to recognize the presence of a dislocation, or a failure on the part of the patient to consult proper authority, is responsible in the vast majority of cases for that lapse of time before reduction is attempted which brings the injury within this category. Occasionally, however, mechanic or other obstacles defeat the best directed efforts of the surgeon at reduction. When months elapse, the dislocation must, as a rule, be regarded as inveterate, though much will depend on the changes which in the meanwhile have occurred in and about the injured parts. In favorable cases the reduction may be effected in the usual manner even after some months. On the other hand, restitution may be impossible. After several weeks special care must be exercised to avoid a fracture of the bone, which may be weakened from long disuse, and to avoid a rupture of adjacent vessels which are liable to be somewhat embedded in the fibrous tissue that has developed. In the atheromatous arteries of the aged the possibility of injury is increased. Delay in reduction may be necessitated by the existence of a fracture of the shaft of the bone close to the articular extremity. Here the leverage necessary for the proper performance of the manipulation of reduction is absent.

The changes which the joint surfaces undergo in unreduced dislocation consist of a filling of the inequalities of these surfaces by means of connective tissue resulting from hyperplastic proliferation of the remains of the torn capsule, and a disappearance of the cartilage. In the case of the shoulder-joint and hip-joint, however, the pressure of the convex end of the dislocated bone on the periosteum of the bone against which it rests leads to irritation of the former and a hyperplastic proliferation of the same, with subsequent new formation of bone. In this manner a substitute for the glenoid and acetabular cavities is formed. A deposit of fibrous and even hyaline cartilage takes place and a new joint results. Under these circumstances considerable approximation to the normal movements may take place, in which case it is not desirable, even if it were possible, to reduce the dislocation.

Habitual Dislocation.—Habitual dislocation is the tendency of a joint, that has once been dislocated and reduced, to become dislocated again from relatively slight causes. This occurs most frequently in the shoulder-joint. It is due either to an interruption of the process of healing by too early movements of the joint, or to a relaxed condition resulting from an overstretching of the capsular ligament before the newly formed tissue of repair has acquired a normal resistance. (Inflammatory and the so-called congenital dislocations are confined almost exclusively to the hip-joint and will be dealt with in the section on diseases of that region.)

JOINT INFLAMMATION

Pathologic Anatomy of Joint Inflammation.—The joint structure consists essentially of four tissues, the cartilaginous, the bony, the synovial, and the ligamentous. The last two, though of the connective-tissue type, differ in several important particulars. The synovial tissue, from the exceedingly rich supply of vessels, is specially prone to inflammatory conditions, while the ligamentous tissue resembles the tendinous in its very slight vascularity, and hence is unimportant in inflammatory processes.

There likewise exist similar important differences between the bony and

the cartilaginous tissue of the joint in relation to inflammation. Chondritis, or inflammation of the cartilage, in consequence of the slight vascularity of this tissue, is rare as a primary affection. Its participation in joint disease is rather the result of neighborhood, its involvement being due to an advancing inflammation of either the adjoining and overlying synovial tissue or the bony tissue beneath. In the former case it is called a **chondritis pannosa,** in the latter, a **chondritis granulosa** or **cribrosa,** from the sieve-like perforations that sometimes take place. Chondritis in this connection is clinically of but slight importance.

Synovitis and Arthritis.—An inflammation affecting the synovial membrane exclusively is known as synovitis. When this extends to the other structures, or when the process begins in the bone or in the whole joint, the lesion is an arthritis. Synovitis is acute and chronic. Acute synovitis is divided into the **serous, serofibrinous, suppurative,** and **catarrhal** varieties. In the milder cases of the disease a simple hypersecretion occurs, with perhaps a somewhat less fluid condition of the synovia, this constituting the simple serous type. In more severe cases fibrin is added (serofibrinous). In still higher grades of inflammatory action emigration of white blood-corpuscles occurs. Except in the milder types, acute suppurative synovitis usually extends to the articular structures. Inflammation of the superficial layer in which a mucinous secretion takes place constitutes the catarrhal variety (Volkmann). Pus also may be added to the latter. In case of wounds of joints, the cocci of suppuration may enter, with involvement of the surrounding structures (abscess or suppuration of a joint).

Chronic synovitis follows chiefly two types: (1) **Chronic serous synovitis,** known as **hydrarthrosis.** Although these cases were once considered dropsical, and not inflammatory, it is now known that the fluid is the result of a low grade of inflammation of the synovial membrane. The membrane is thick and boggy with a slight increase in vascularity. The fluid is colorless or light yellow, containing mucus and albumin. It is usually present in large amount and greatly distends the capsule. (2) **Granulating** or **tuberculous synovitis.** This is not necessarily an independent disease. It frequently develops from a pre-existing granulating myelitis of the articular extremity of the bone, reaching the synovial membrane after destructive invasion of the cartilage, and thence the joint cavity. During the early stages of tuberculous synovitis there are two distinct types: in the one the tuberculous infection produces a pulpy degeneration of the entire sac with but little effusion of fluid, the swelling being due to the thick layer of granulating tissue; in the other the granulating tissue, though present, is more scanty and the fluid is abundant. These cases are also known as **tuberculous hydrops** (Senn). Both may develop into a complete tuberculous arthritis (*vide infra*).

Hyperplastic Synovitis.—This may either occur independently or represent the final stage of serous, suppurative, or granulating synovitis. The fringe-like processes found in joints after inflammatory conditions represent the proliferations resulting from hyperplastic synovitis. Opposing walls of synovial pouches, as well as the articular extremities of bones bared of cartilage, may become agglutinated, producing adhesions (**fibrous ankylosis**). Not infrequently bone is developed in these connective-tissue layers leading to **true ankylosis.**

Papillary Synovitis.—This is a form of hyperplastic synovitis occurring not infrequently in old age. The proliferation occurs in the shape of villi, or flattened fibrous indurations. While these are so frequently found as to be looked upon almost as a normal condition, yet, by their increase in number and size, they may give rise to symptoms of disease, particularly in connection with **senile polypanarthritis** or **arthritis deformans** (see below).

Arthritis, or inflammation of the joint as a whole, may, like synovitis, be either acute or chronic.

Acute Septic Arthritis.—This lesion, however caused, is fairly constant. The synovial fluid is increased in quantity, it soon becomes cloudy, and finally distinctly purulent. The cartilages become blue and soon ulcerate. The ligaments are weakened and stretched and give way, permitting the joint contents to traverse the soft parts in all directions and a displacement of the joint surfaces to occur. An acute osteitis with ulceration or necrosis as a result, beginning at the joint surface, may extend to the shaft of the bones. The periarticular tissues become acutely inflamed and abscesses appear in all directions; these are often very large, and, spreading in the planes of the muscles, may extend a distance from the joint.

Chronic Arthritis.—Here the lesion varies more, this variation depending on the etiology. Many cases are cases of **tuberculous arthritis.** The bacilli may be situated at first in the synovial membrane and a granulating synovitis precede the complete arthritis; or a tuberculous osteitis, situated usually at the epiphysial line, may extend by the erosive action of the granulations (caries), or by a wedge-shaped infarction (necrosis) due to the cutting off of the blood from a section of bone by the inflammatory products resulting from the osteitis. The escape of tuberculous material from the bone into a joint is followed by a diffuse tuberculous arthritis affecting the synovial membrane, the cartilages, the ligaments, and in time the other bones. The joint cavity is filled with the degenerated products of the tuberculous process (so-called cold abscess), but it does not partake of the character of a septic arthritis until the cocci of septic infection become added to the tubercle bacilli. This occurs when the ulcerative process reaches the surface, or it may occur indirectly through the system.

Arthritis Deformans (Rheumatoid Arthritis, etc.).—The lesion here is chiefly a slow degeneration, usually beginning in the cartilages. It is accompanied by a slow but abundant growth of cartilage and bone, especially along the margins. This hypertrophy is irregular in shape and has a low grade of vitality. It wears away when friction occurs, or breaks off and forms loose bodies in the joint. The bones are increased in size by this irregular hypertrophy, and the projections may interfere mechanically with the movements of the joint. The capsule and ligaments undergo fibrous degeneration, and contract, forming adhesions that also interfere with the motion. In advanced cases the tendons in the neighborhood may degenerate so that the attachment to the bone disappears. Ossification may occur in the capsule and tendons. Suppuration is seldom, if ever, present. The interior of the joint is usually dry, but in some cases it contains a large amount of fluid.

Tabetic Arthropathy (Charcot's Joint Disease).—The lesion resembles osteoarthritis, but the degeneration is more extensive and the hypertrophy much less. The ligaments become very lax, permitting much lateral move-

ment, and the joint is swollen, containing fluid and many loose bodies that result from the rapid degeneration.

Etiology of Synovitis.—**Acute synovitis** is usually due to an injury. A sprain, a contusion, a simple dislocation, a fracture entering a joint, are the more common causes. An aseptic wound may produce a serous synovitis. Some cases are nontraumatic in origin.

Synovitis may also result from too prolonged use of a joint, particularly in cases of relaxation of the ligamentous apparatus and muscular structures. After prolonged rest of the part, as, for instance, fixation of the knee-joint following a fracture of the thigh, the first movements tend to produce a serous synovitis. As septic synovitis is usually present in the beginning of a septic arthritis, its etiology will be mentioned under that head.

Chronic Serous Synovitis.—This often follows an incomplete cure of an acute case, especially in a patient with rheumatic tendencies. A displaced cartilage, a weakened ligament, or a floating body may by many slight traumatisms result in chronic synovitis. Some cases are thought to be due to constitutional syphilis.

Granulating or Tuberculous Synovitis.—These cases are due to the presence of the tubercle bacillus. An injury by itself cannot produce this disease, but an injury may so lower the powers of resistance in a joint that a person who is already suffering from an active tuberculous process or from miliary tuberculosis (see page 207), or who afterward becomes so infected, may develop a tuberculous synovitis. Clinically in about one-half the cases a history of injury is obtained. This disease also frequently occurs in children whose condition is depressed from a preceding attack of one of the exanthemata. A hereditary tuberculous history has been thought by some to predispose a child to this condition after a slight traumatism of the joint. The large majority of these cases occur in childhood.

Acute Septic Arthritis.—**Suppurative inflammation** of joints arises from penetrating wounds of the joint, gunshot and otherwise, compound fractures, and compound dislocations. In addition, suppurative processes may be added to the forms of inflammation which are propagated from the adjoining periosteal, medullary, and osseous tissues (suppurative osteomyelitis, granular osteomyelitis, and periostitis).

Metastatic Joint Inflammation.—In addition to joint inflammation of local origin are to be considered the inflammations in which common pus cocci pass from the blood into the tissues or, in cases of pyemia, on the free surface of the synovial membrane (see page 184). Likewise a primary tuberculous synovitis must necessarily occur in the same manner, though without doubt a trauma lessens the local vital resistance of the part, and serves as an exciting cause.

Metastatic inflammation of joints may likewise follow many of the acute infectious diseases, such as variola, measles, typhus, typhoid, dysentery, etc. In typhoid fever but one joint, and that the hip-joint by preference, is attacked by metastatic inflammation. Pathologic or inflammatory dislocation is liable to follow.

Acute rheumatism or polyarthritic synovitis (H u e t e r), on account of the frequency and importance of complications affecting internal organs, is generally treated of in works on general medicine. It is possible for pus

cocci to be added to the specific infection here present, though this condition is rare. A suppurating joint may follow.

Arthritis Uratica.—The condition known as the uric acid diathesis gives rise to a form of arthritis. The joints of the toes are particularly liable to this affection (podagra). This, like the preceding, is described in works on general medicine.

Gonorrheal Arthritis.—It occasionally happens in the course of acute gonorrheal urethritis, especially in the later weeks, that a metastatic arthritis due to the emigration of the specific organism of the disease, the gonococcus of Neisser, occurs in a joint. The knee-joint is the part most frequently attacked, though any articulation may become the seat of the infection. This disease is occasionally, though improperly, called **"gonorrheal rheumatism."** It follows the course of a septic arthritis, but is usually of a milder type than the ordinary pus-joint.

Tuberculous arthritis arises from a tuberculous synovitis or from a tuberculous osteitis, usually at the epiphysial line. The etiology of osteoarthritis is still unsettled. Rheumatism and gout perhaps predispose to this condition. There is often a history of heredity. In a predisposed person it often develops after traumatism. The view more recently advocated places its cause in a degeneration of the trophic nerves. It is more prevalent among those whom poverty and exposure have weakened.

Tabetic Inflammation.—Charcot, in 1868, pointed out the relative frequency of joint affections in patients suffering from tabes. He asserted that they appeared by preference in the earlier stages of the disease. Rotter and Kredel, however, in studying the statistics of the affection, showed that in the majority of severe cases the advanced or ataxic stage of the disease was chosen. It was therefore suggested by Volkmann that these arthropathies were really due to traumatic influences on joint structures deprived of proper nerve-supply and hence the subject of nutritive disturbances and atrophic changes.

Clinical History of Serous and Suppurative Synovitis.—When the joint is at rest, neither pain nor fever is a pronounced symptom in serous synovitis, unless a rheumatic element is also present. Motion is restricted by the presence of the effusion and by the pain caused by attempted movements. Local heat is present but not marked, and the patient holds the joint in a partially flexed position. There are no pronounced constitutional symptoms.

Suppurative Synovitis.—Considerable pain and fever are characteristic symptoms of joint suppuration. General septic infection rapidly follows this condition, marked by irregular chills and the general symptoms of fever; the temperature varies from 102° F. to 105° F. With the involvement of surrounding structures and the rupture of the capsular ligament, the arthritic inflammation lessens in severity. The fever may abate and granulations spring up in the joint cavity. The cicatricial formations which follow may obliterate the joint, and recovery finally take place, with loss of function of the articulation. In large and complicated joints, if free exit is not given to the pus and antiseptic treatment instituted, the products of suppuration are retained and absorption of toxemic infectious agents, or prolonged suppuration with new foci constantly developing, leading to amyloid degeneration of abdominal organs, may destroy the patient.

Metastatic Suppurative Synovitis.—This may be accompanied by but slight local symptoms. The general symptoms are those of the original condition from which the infection was derived. It is sometimes found at the autopsy when no suspicion of its presence existed during life. At other times the joint condition is the chief lesion of a pyemia (see page 184).

Clinical History of Tuberculous Joint Inflammation.—The course of a favorable case of tuberculous joint disease, when treated mechanically, is from one to three years. If this treatment is efficient and the general health improved by the administration of tonics, the process may stop at any point and repair be instituted with a more or less perfect recovery of motion, the latter depending on the extent of the process. But the process may go on in two ways: (1) In those instances in which tuberculous synovitis does not tend to secondary suppuration the disease passes by infection into all the adjacent tissues. The resulting granulating inflammation produces fusion of the ligaments, cartilage, and bones of the joints, as well as of neighboring bursae, sheaths of tendons, and the tendons themselves. The skin itself finally becomes involved, and, with the occurrence of suppuration and ulceration, fistulous canals lead to the interior of the diseased joint. Spontaneous closure of these is very rare. As one closes, another opens, until death comes to the patient's relief. This may take place from general miliary tuberculosis, particularly of the lungs, or by tuberculous enteritis or meningitis. Amyloid degeneration of the spleen, liver, and kidneys likewise leads to a fatal result. Enlargement of the liver and spleen and albuminuria from the kidney involvement characterize this condition. Amyloid degeneration of the mucous membrane of the bowels leads to chronic and intractable diarrhea. This may occur simultaneously with general tuberculosis. Septicemia and pyemia may occur at any time during the course of the disease. (2) The joint may take on a septic process before any direct opening ulcerates through, and the patient suffers from the mixed infection. The case is then clinically an acute septic arthritis and should be so treated. The first method, however, is the usual one followed by tuberculous joints when they take an unfavorable course.

The simplest form of **hyperplastic synovitis** is that in which a thickening of the reflection of the synovial membrane over the intra-articular cartilages occurs. From the resemblance of this to the thickening of the conjunctiva over the cornea, called pannus, this variety is called **synovitis pannosa** (Hueter). The only danger to be anticipated from pannous synovitis is the occurrence of adhesions between two opposing surfaces, leading to subsequent limitation of movements of the joint.

Hyperplastic Papillary Synovitis.—This form is so intimately associated with villous thickening of the rest of the structure of the joint that it is difficult to differentiate it clinically. It is very slow in its course, extensive fibrous induration of the capsule and thickening of the bony structure occur, and, in the case of superficially situated joints, considerable deformity may result. On this account it has been called **arthritis deformans.** This name, however, necessarily implies a deformity, which does not always occur. From the fact that all of the component parts of the joint are more or less involved, the term **hyperplastic polypanarthritis** has been suggested (Hueter). In the majority of cases a single joint, or a group of joints, as the fingers, is attacked. Pain on movement, cracking or grating sensations, and, finally, restriction of the movements of the involved parts are the prominent symptoms.

General Diagnosis of Inflammation of Joints.—Inspection.—Usually swelling is present. Often this is made more pronounced by an atrophy of the muscles over the adjoining bones, as, for example, the spindle shape in a case of tuberculosis of the knee caused by the swollen joint and shrunken thigh and calf. In other cases, however, the atrophy of the muscles directly over the joint may compensate for the inflammatory swelling. Under these circumstances the diseased joint may be smaller in circumference than the corresponding healthy joint. Only exceptionally the inflamed joints appear red, viz., in the acute septic cases, and then only when the overlying tissues are involved. Many chronic cases appear white from the deficient circulation in the skin that is stretched by the swelling. By inspection we note also the position. An inflamed joint is held at the angle that will produce the least amount of tension in the capsule. Usually this is a slightly flexed position.

Palpation.—The presence or absence of fluctuation, as well as of edematous conditions of the surrounding parts in the beginning of the disease, and of fibrous indurations later, is to be determined by palpation. The presence of softening in the midst of an indurated surface is an evidence either of a more rapid advancement of a granulating inflammation or of the occurrence of abscess. Friction sensations are conveyed to the hand by palpation, which may be due to the presence of foreign bodies, deposits of fibrin, loosened portions of necrotic cartilage, loosened epiphyses from inflammatory action, the friction of the bony joint surfaces deprived of their cartilaginous coverings, etc. These will vary in quality and other characteristics according to the causes producing them. Slight limitations of motion are discoverable only by careful comparison with the sound side and by the gentle movement of the joint through the full extent of normal range. This limitation is often the first symptom of a chronic joint affection. When, as is often the case, it is due to muscular spasm, it disappears under an anesthetic. While normal movements may be restricted, abnormal movements, particularly in joints in which lateral movements are not possible in healthy conditions, may be present, from relaxation or destruction of otherwise limiting ligamentous structures.

Local elevation of temperature is also discoverable by palpation, in acute inflammations, but is absent in those following a chronic course. Thermometric observations are best carried on by the aid of the clinical thermometer. Evening rise of the general temperature indicates either a suppurative process or a general infection, tuberculous or otherwise.

Prognosis of Inflammation of Joints.—This relates (1) to the function of the joint; (2) to the general health and life of the patient.

Acute serous synovitis under proper treatment is usually cured, leaving a perfect joint. If improperly treated, or where the cause is often repeated, it may reach the chronic stage. In predisposed or weakly persons it may be the foundation of a tuberculous synovitis. **Chronic serous synovitis** causes a relaxation of the ligaments and a weakened joint.

Acute septic synovitis, if energetically treated by proper means, may give a fairly good functional result, though probably never a perfect one. Usually, however, a fibrous or osseous ankylosis follows, if, as frequently occurs, a septic arthritis develops.

High grades of septic inflammation in a large joint may be followed by a

fatal result. Even a finger-joint, the seat of suppurative inflammation, may become a source of danger, the suppuration advancing in the synovial sheath of a tendon. In acute suppurative inflammation death takes place from septic and pyemic complications.

Early cases of **tuberculous synovitis,** occurring in individuals whose general health is good and in whom the amount of tuberculous infection is slight, often yield a surprisingly good functional result after careful and prolonged mechanic treatment. In most cases, however, there is more or less restricted motion and a shortening of the limb. These cases may result fatally from exhaustion, acute general tuberculosis, acute phthisis, or tuberculous meningitis. Amyloid degeneration of the abdominal organs may supervene.

The prognosis in **osteoarthritis** is in the direction of slowly developing increase of all symptoms; these can be relieved and arrested, but seldom, if ever, entirely cured. Total disability results in extreme cases.

Treatment of Inflammation of Joints.—**Acute synovitis** requires **rest.** This must be complete. The apparatus applied to effect this must itself not give pain. (For the various methods for the different joints see Regional Surgery.) The coil with ice-water, or the ice-bag, is of great value. An average case requires but little general treatment except a laxative and perhaps a sedative. Patients with a rheumatic tendency, although the joint trouble is traumatic, are often relieved by the salicylates.

Septic synovitis requires free incisions and complete drainage with antiseptic irrigations, in addition to proper splints.

In **chronic serous synovitis** marked by persistent effusion, moderate compression and the actual cautery may be tried before puncture and irrigation of the joint cavity. While in this class of cases, as well as in **parasynovitis,** much benefit may be derived from compression and massage, in granulating synovitis their employment is not followed, as a rule, by the same favorable results. Compression is best applied by means of the "circular bandage" so called, as used for varicose veins.

Treatment of Tuberculous Synovitis.—In this form of inflammation the microorganisms which produce the local disturbances invade the tissues from the blood. In this sense, therefore, it is a local manifestation of a general infection, and requires, as well as local treatment, a regard for the patient's general health. This will include nitrogenous food in ample quantities, pure air, and the best hygienic surroundings.

The employment of such **local measures** as blistering and the use of the thermocautery in the treatment of tuberculous synovitis has not yielded very satisfactory results. Fixation and cauterization, when combined with a vigorous effort to restore the general health, is occasionally followed by improvement. Intra-articular medication, consisting of the introduction, by means of a trocar and an injecting syringe, of Peruvian balsam or of a 10 per cent emulsion of iodoform in glycerin (Bruns), is a far more rational procedure and worthy of more extended trial.

When the disease has advanced to the stage of suppuration, the most radical measures are necessary for its relief. These consist in **resecting** the joint surfaces, and scooping out with Volkmann's sharp spoon, or thoroughly cauterizing by means of the thermocautery all suspicious foci

(for Evidement, see page 369). The entire synovial membrane is to be dissected away and all fistulous tracts are to be curetted thoroughly or removed. Simple scraping and cutting away of the diseased synovial membrane (Erasion, see page 372), with or without partial resection (Arthrectomy, see page 372), is a measure not so well calculated to achieve the best results as typic resection and evidement. Reinfection, as evinced by the failure of the parts to heal promptly, demands a repeated application of the sharp spoon and thermocautery.

Widely varying opinions exist as to the benefit to be derived from the **mechanic treatment** of joint disease. While the orthopedic surgeon is inclined to rely almost exclusively on this, the general surgeon, less familiar with complicated apparatus, and more at home in the operative field of work, advises and employs methods of a more radical nature. It is probably true that mechanic treatment is of the greatest service in the very beginning of joint disease, particularly in that of the hip-joint, though in the later stages of tuberculous disease of joints its effect has been very greatly overestimated. Mechanic treatment, to be most effective, must fulfil the following three indications: (1) **fixation**; (2) **extension**; (3) **protection.** By the latter is meant preventing all traumatism or weight from affecting the inflamed joint. Unless these three indications are provided for, **rest** is not perfect, and but little can be accomplished mechanically in the way of arresting or curing a tuberculous process. Though these methods of treatment are in a great measure symptomatic, yet they serve a very important purpose, both locally and generally, and can be carried on while intra-articular injections are being practised. Fixation may possibly assist in preventing dissemination of the infection, which is more or less favored by movements of the joint.

Another object of mechanic treatment is the correction of malposition of the limb. This is effected by converting in a gradual manner, the flexed into the extended position by means of traction by weight and pulley extension, combined with apparatus which utilizes the weight of the limb itself to accomplish the object (for special apparatus, see Regional Surgery).

The mechanic treatment will include **local compression** and **massage.** These are to be employed only after the acute symptoms have subsided; they are more or less useful in promoting restoration of function, but they take no part in the cure of the disease itself.

Osteoarthritis.—The treatment in this case is an exception to the general rule that joint diseases require immobilization. Except during acute exacerbations of the process, active and passive motions with massage, etc. should be advised. Steaming the joint daily in hot flannels relieves much of the pain. Blisters and the actual cautery are useful. In early cases iodid of iron and sometimes arsenic is indicated. Hygiene and an out-of-door life are of great importance in arresting the progress of the disease. An annual "cure" at one of the alkaline or sulfur springs may temporarily improve a case.

Periarticular Inflammations.—It may happen that an inflammation, usually suppurative in character, occurs in the tissues surrounding a joint. A contusion resulting in a collection of effused blood outside the ligaments becomes infected through an abrasion, or through the blood-channels from a distant focus, and a condition arises which, in its local aspects and constitu-

tional symptoms, closely resembles a septic arthritis. Tenderness and pain on motion, loss of function, and general sepsis are present. It is not easy to diagnose some of these periarticular inflammations. It may be noted that the characteristic position assumed by the joint in question, when it is the site of a septic arthritis, is absent. This is due to the fact that intra-articular tension is not present to cause the position. The onset of these cases is also less abrupt, as the absorbing surface is less extensive.

The treatment of these cases is incision and drainage; this should be prompt, so as to protect the adjacent joint. The prognosis for a full recovery of function is excellent.

CONTRACTURE AND ANKYLOSIS

Contracture.—A restriction of the normal range of motion in a joint constitutes a contracture.

Cicatricial contractures arise from the action of more or less extensive cicatrices, these usually resulting from burns and scalds and situated on the flexor aspect of the limb. The skin alone, or the skin and the fascia and muscles in addition, may be involved in the cicatrix. The joint is not necessarily involved, though secondary changes, from pressure and position, may take place in the articulation.

Myogenous and tendogenous contractures are consequent on injuries and inflammation of the muscular apparatus. The muscles may be prevented from moving independently of one another, or they may be shortened from nutritive disturbances following rupture, or from cicatricial deposit following the accident, as, for instance, the wry neck after a breech delivery. Familiar examples of tendogenous contracture are found in the contracted fingers so commonly observed to follow phlegmonous inflammation of the palm of the hand, and involving the sheaths of the flexor tendons.

Neurogenous contracture develops after paralysis of the motor nerves, the muscles undergoing nutritive shortening. **Pes paralyticus** is the most important of the contractures in this group. Here the muscles that are paralyzed suffer from the continual tension to which they are subjected, while the muscles that still receive a proper nerve-supply become permanently shortened by a constant approximation of their points of origin and insertion, from absence of an opposing force. Paralysis of a single nerve trunk may complicate the conditions. Neurogenous contractures of the hand and fingers are usually distinctly defined.

Arthrogenous Contractures.—This group finds its origin in the joint apparatus itself, and is of the greatest importance in its bearing, especially on the prognosis of arthritic inflammation. Etiologically, arthrogenous contractures may be divided into those which are congenital and those which are inflammatory. The first named appear as contractures of the foot (congenital clubfoot); less frequently as contractures of the carpus (congenital clubhand); finally, still more rarely as congenital knock-knee, or genu valgum (see these deformities).

Among the most important sequels of arthritis are the arthrogenous contractures. They form the great majority of cases of this class coming under observation, hence their importance. When due to the presence

of an acute synovial inflammation, on the disappearance of this in most instances they vanish in whole or in part. In other cases some disturbance of function, more or less permanent, results. The contracture due to tension of the joint capsule in large effusions within the joint is likewise, as a rule, only temporary. **Granulating inflammation** within the capsule, however, interferes greatly with the movements of the joint. Cicatricial contracture of the capsule prevents it from following the joint movements. In cases of osteo-arthritis the swelling of the bony substance likewise restricts the movements. Proliferation of the cartilaginous or synovial tissue will offer mechanic obstacles as well. The indurations remaining in the subsynovial connective tissue after suppurative inflammation of the synovial membrane interfere more or less with the mobility of the joint.

Fracture in the neighborhood of a joint or communicating with it, by an abundant formation of callus may restrict its movements very seriously. In the case of the elbow-joint, particularly, the deposit of callus in the capsule (the so-called ossification of the capsule) is of great importance. Projecting masses of callus having their origin in the torn periosteum, or in displaced centers of ossification in children, also hinder the movements of the joint. Finally, hyperplastic synovial inflammation, giving rise either to vascular processes in two or more portions of the joint which become adherent, or to direct adhesion of two opposing surfaces, as in pannous synovitis, may seriously cripple the usefulness of the joint.

Ankylosis.—This term means literally an angular, bent, or crooked joint. In this sense it may be applied to most contractures. It is properly applied, however, to joints which are incapable of movements, whether in the flexed or in the extended position.

False Ankylosis.—This term is applied to those cases in which joints, apparently immovably fixed, can be moved throughout the normal range, under an anesthetic. Muscular spasm of these cases is the cause of the rigidity.

True Ankylosis.—This signifies a solid attachment of two articulating surfaces. Three varieties are distinguished: (1) the fibrous; (2) the cartilaginous; (3) the osseous.

Fibrous Ankylosis.—In this variety movements may be impossible, or a certain amount of mobility may be present. The extent of motion will depend on the firmness of the tissue connecting the joint surfaces. This tissue is derived from either the synovial membrane or the connective tissue of the medullary structure. In the first case it occurs in the shape of smooth projections from the border of the capsular insertion on the joint surfaces. Two layers of connective tissue, therefore, are present, each progressing over its corresponding articular surface. These may unite directly, the underlying cartilages becoming attached to each other through the medium of these layers of newly formed tissue. In cases in which the cartilage has been destroyed in consequence of an advancing granulating myelitis, the bony tissues themselves are connected by means of this connective tissue, which, soft at first, may, in consequence of cicatricial contraction, become firm and fibrous.

Cartilaginous Ankylosis.—The fibrous form may become converted into the cartilaginous by the development of cartilage in the connective tissue covering the still intact joint cartilages. This variety may occur after granu-

lating synovitis and suppurative conditions; it is most frequently observed, however, after fractures communicating with the joint.

Osseous Ankylosis.—Bony ankylosis may develop after either the fibrous or the cartilaginous form. In the former case a cicatricial development of connective tissue occurs, the cartilage being destroyed in whole or in part by a granulating myelitis. This cicatricial tissue contracts and gradually ossifies in very much the same manner as callus in union of fractures. In the latter case the cartilaginous strip, which still remains intact, ossifies.

It is therefore evident that ankylosis appears first as fibrous; this may subsequently be converted into the cartilaginous and thence into the osseous, or may pass directly into the osseous. In either case the transformation is necessarily very slow, occupying years for its completion.

Treatment of Contracture and Ankylosis.—While every effort should be made to preserve as far as possible the full range of movement in the limb, it will occasionally happen that, in spite of every precaution, ankylosis occurs. Under these circumstances it is imperative that the position of the joint should be such as to insure the greatest usefulness to the limb. In the case of the knee, this will be in an almost extended position, and in the elbow, at a right angle.

The treatment of both contracture and ankylosis may be divided into (1) manual passive movements; (2) manual correction under an anesthetic; (3) correction by weight and pulley extension; (4) correction by instrumental means (pressure and traction); (5) tenotomy; (6) resection; (7) osteotomy; (8) amputation.

Manual passive movements should be first attempted. Slight contracture of short duration will frequently yield to these. Passive movements promise success when an increase in the range of motion is evident on measurement. When night pains follow the employment of passive movements, no improvement is to be expected, as a hyperplastic inflammation is being set up which tends to increase still farther the rigidity. They must then be employed less vigorously or give place to other methods. When they have failed, **manual correction under an anesthetic** may be resorted to, in which considerable tearing of the tissues results. This forced correction should not be applied to tuberculous joints until all active processes have ceased. Even then it may arouse a latent focus to renewed activity. This may or may not precede the third method, that of **correction by weight and pulley extension.** The latter is usually resorted to when the deformity results from excessive irritability of the muscular structures due to an active inflammatory condition.

Correction by instrumental means consists in the adaptation of apparatus which accomplish the object by gradual pressure and traction, such, for instance, as in congenital clubfoot and knock-knee (see these deformities).

Tenotomy or myotomy may be substituted for the above in cases in which the contracture is of tendinous or muscular origin. It is employed also in cases in which it is necessary to remove resistance of tendons in order to permit other methods of treatment, *e. g.*, extension by traction in ankylosis of the knee after section of the hamstring tendons.

Resection of the diseased joint, or of such portions thereof as are necessary for the correction of the deformity, constitutes a very effective method of

treatment. It is particularly useful in cases in which a newly formed joint may develop (see Resection of Wrist-joint, Elbow-joint, Shoulder-joint, etc.).

Osteotomy.—Osteotomy is specially applicable to the hip-joint and the knee-joint. It is performed by saw or chisel, applied as near the apex of the deforming angle as possible and followed by a proper adjustment of the sawed surfaces.

Amputation is a last resort. It is to be employed only when total loss of function or extensive ulceration occurs. This method, however, has been practically abandoned.

Compound methods are frequently employed, as, for instance, tenotomy and correction under anesthesia, or osteotomy and subsequent mechanic treatment. Manipulation under anesthesia, tenotomy and myotomy (Phelps), and retention by means of plaster-of-Paris bandages are specially useful in congenital talipes.

Some forms of **fibrous ankylosis,** as well as **false ankylosis,** may be treated by one or both of the first two methods, namely, instrumental correction or tenotomy. **Bony** and **cartilaginous ankylosis,** however, and some forms of fibrous ankylosis will require **resection** or **osteotomy.**

Movable Bodies in Joints.—These are the consequence either of injuries or of arthritis deformans. When the result of injuries, portions of the articulating surfaces or interarticular cartilages are torn off. These may remain attached and become subsequently detached by sudden movements of the limb. They are rarely observed elsewhere than in the knee-joint or the elbow-joint. When the result of arthritis deformans, they may have their origin in the pediculated synovial villi. They may likewise be found in the sheaths of tendons which have been the seat of tendovaginitis, as well as in bursae following bursitis. Here they occur as quite small rounded bodies which resemble grains of rice (oryzoid bodies). Or, movable bodies the result of arthritis deformans, may occur in consequence of the pediculation of the free edge of cartilaginous and bony proliferations, which subsequently become torn off. Even after becoming loosened they may continue to grow, receiving their nourishment from the synovial fluid.

Diagnosis.—The symptoms of movable body in a joint depend on (1) the size of the body; (2) the particular joint involved. Large bodies give rise to much less disturbance than small ones. The latter, by becoming pinched between the articular surfaces, cause a sudden arrest of the movements of the limb, and more or less pain. The discomforts arising from pain in the joint are much greater in the case of the knee than in that of the elbow. In the case of the latter, the pain is, as a rule, not very severe; on the contrary, in the case of the former, it may be sufficiently acute to cause the patient to swoon. In many cases the movable body becomes fixed in some recess of the joint where it does not interfere with the joint functions, and thus all symptoms are absent for a long period of time.

Palpation is employed to establish the presence of the movable body. This may be difficult, owing to the fact that in some localities thick overlying parts intervene. The patient will usually be able to locate the body when every effort on the part of the surgeon to do so has failed.

The **treatment** consists in removal of the movable body by incision, after its presence and location have been assured positively (see Regional Surgery).

Synovitis of the Sheaths of Tendons, Tendovaginitis, Tendosynovitis.—Tendinous sheaths are lined with a synovial membrane which is identical in every particular with that which lines the interiors of joints. Analogous conditions involving the necessity of preventing friction exist in tendons and joints. Certain tendon-sheaths have direct communication with the joint (the popliteus with the knee-joint, and the long head of the biceps with the shoulder-joint).

Tendovaginitis assumes the same forms as synovitis of the joints. If the disease is due to a direct injury, hemorrhage may accompany the effusion of serum. Fibrinous deposits in the sheath give rise to crepitating sounds which are quite characteristic. The affection has its origin in excessive strains on the tendons when certain difficult and unusual movements are executed. It is commonly seen about the wrist in tennis players from the use of the racket, and in plasterers from the use of the trowel. The fibrous type is best treated by immobilization and counter-irritation with tincture of iodin for several days. The serous variety, showing the swelling and not the crepitation, requires the use of splints and lotions. The few cases that are wholly or in part rheumatic in origin require constitutional medication as well.

Suppurative Tendovaginitis.—Suppurative inflammation of the sheaths of tendons is almost exclusively observed in cases of septic wounds involving these sheaths. It may be exceedingly rapid in its progress, a septic infection at a phalanx reaching the forearm in twenty-four hours by this route. Necrosis of the tendon also occurs very rapidly under these circumstances. If the tendon escapes, granulations spring up, and both tendon and sheath become adherent in the resulting cicatrix. Early and free incision and antiseptic treatment are imperatively demanded.

Tuberculous Tendovaginitis.—This occurs very rarely as a primary affection, but is the result of extension from neighboring diseased bones and joints.

Papillary tendovaginitis is a hyperplastic inflammation of the sheaths of tendons. The papillae become separated from their attachments by constriction, forming the so-called oryzoid or rice bodies. They probably arise from the small synovial recesses which are found in the normal state closely attached to the tendinous sheaths. The extensor tendons of the fingers are most frequently affected. The bacilli of tuberculosis have recently been demonstrated in these rice bodies. An excision of the affected part of the sheath is the treatment advised for these cases.

Ganglions.—These are protrusions of the synovial sheaths through their fibrous coverings. They are, in fact, hernial pouches. A strain is a frequent cause. Clinically there are seen semispheric tumors of more or less density that do not involve the skin but move with the tendons. They have the same inflammatory actions as joints. They are to be differentiated from chronic dropsy of the sheath both by the absence of fluctuation in the solid variety and by the correspondence of the swelling to the length and breadth of the sheath in the dropsical conditions of the tendons. When the tension is very great, fluctuation is absent in the gelatinous form as well. Some of these ganglions though appearing near the tendon, when dissected out will be found to arise by a pedicle from the joint, and are really protrusions of the joint synovial membrane. The acute cases are simply serous in character, as a rule,

and require only subcutaneous puncture. Other cases of greater density are of a serofibrinous type and should be dissected out. Still others are tuberculous in character and progressive in their course, requiring a prompt radical excision before neighboring tendon-sheaths and joints are involved.

Bursitis.—The bursae mucosae are lined with synovial membrane, which may become the subject of inflammation. This may be serous, serofibrinous, or, in the case of the prepatellar bursa, suppurative, as in joint synovitis. These bursae are sometimes situated near large joints, and inflammatory processes may extend from one to the other, as, for instance, the bursa of the iliopsoas and of the hip-joint, and that of the subscapularis and of the shoulder-joint. Rarely a bursa may be the seat of a primary tuberculous synovitis.

SECTION III

GUNSHOT INJURIES

Definition.—The term "gunshot injury" is usually applied to those injuries caused by missiles propelled by means of a sudden violent expansive force. Besides injuries which result from projectiles discharged from some of the various kinds of guns and firearms in common use, those which result from missiles projected by violent explosive force other than that imparted to them by the aid of guns, such, for instance, as fragments of a shell, canister shot, and shrapnel bullets, as well as substances propelled by the explosion of military mines, are comprehended under the same term. In fact, any substance driven with sufficient velocity, and hence violence, through the agency of an expansive force will produce injuries which to all intents and purposes are gunshot injuries. The great majority of wounds of this class coming under the care of the surgeon, however, are caused by bullets from such portable firearms as rifles, pistols, and muskets.

The General Characteristics and Distinguishing Features of Gunshot Injuries.—Every conceivable variety of injury capable of being inflicted on the human frame by violently propelled obtuse bodies is embraced in gunshot injuries. The leading characteristic of these lesions is the constant presence of the features of either contusion or laceration, or of both, in connection with the injury. The former may be present as a simple bruise of the surface from contact with a spent ball, or it may involve complete destruction of deep-seated structures or organs with very little superficial injury. The elements of both contusion and laceration enter in the case of penetrating gunshot wounds, though these may vary from mere division of the skin to the most extensive shot canals, or the shattering of the tissues with which the bullet may come in contact. The variations present in gunshot injuries in general depend on the following: (1) The physical qualities of the projectile. These relate to its form, weight, the material of which it is composed, its dimensions, volume and density. (2) The qualities which the missile derives from the arm from which it is projected, namely, its velocity and rotation. (3) Qualities imparted to the missile during its flight, such as the resistance offered by the air through which it passes, its passage through media of different densities or through resisting bodies, deviations from its normal course or from the direction of its longitudinal axis (ricochet shots), etc. (4) The heat developed during the flight of the bullet, which has been supposed by some to affect the wound. In addition, the quality of poison added to the bullet, from which it is transferred to the wound, may have to be taken into account. (5) Conditions pertaining to the part of the body struck, such, for instance, as the relative position of the part struck to the missile (the angle of impact), the location of the injury, and the course taken by the projectile after it enters the body. (6) The entrance of foreign bodies into the wound, such as portions of clothing, gun wadding, splinters of wood, etc.

The Shape and Size of the Projectile.—In the case of the larger projectiles the crushing effects and disturbances of neighboring parts are such that but slight influences are exerted by the forms of these projectiles on the character of the injuries that they inflict. On the other hand, the wounds made by the smaller projectiles, or those discharged from rifles, pistols, etc., present variations according as the bullet is spheric, of the combined cylindric and pointed arch form (the so-called cylindro-ogival), or cylindroconoidal. The diameter of the bullet likewise exercises an important influence on the character of the injury. In the case of the spheric bullet there is more or less of a diffused concussion effect radiating from the point of impact (Longmore). This effect is less marked in the pointed arch and cylindroconoidal forms, and progressively lessens as the diameter of the bullet is decreased. The latter circumstance, namely, the decrease in diameter, as well as the smoothness of surface, such as exists in the steel-mantled, nickel-mantled, and copper-mantled bullets, greatly increases the penetrative power of the projectile.

The question of **deformation** of the projectile has a direct bearing on the character of the injury. The intrinsic tendency of the round bullet to deformation is slight, on account of its minimum amount of so-called "internal energy"; in the modern oval and long bullet this tendency is greater and has necessitated the application of a jacket or mantle to prevent marked bending and splitting. These deformations are caused by the resistance met with in the tissues resulting in a reciprocal back action on the projectile through which a portion of its intrinsic power is converted into deformation and heat in such a manner that both effects are equal (Reger). The velocity being the same, in the case of the unprotected bullet the deformity increases with the resistance; in the case of the protected bullet the heat increases. Again, the resistance being equal and the velocity increasing, the deformity increases in the unprotected bullet and the heat increases in the protected bullet.

The deformity of the projectile influences the effect of the bullet in a marked degree. The effects are more extended, and, as a result of an increase of the resistance and a decrease of the penetrating power, the deformity still further increases, so that the bullet either lodges in the tissues, or in emerging, causes the most bizarre effects. This is specially true in cases in which the bullet has passed through other living bodies or through breastworks. If the deformed missile has sufficient energy remaining, it may still exert a radiating concussion (explosive effect).

The effect known as **mushrooming** is a still more pronounced deformation, and is more especially marked in the so-called Dumdum bullets. This effect may take place in jacketed projectiles that strike hard objects, either before or after they enter the body, or it may be produced by tampering with the jacket of the projectile.

In the majority of cases gunshot wounds inflicted by the modern small-bore, elongated, high-velocity projectile have two apertures, one made by the entrance of the missile and the other by its exit. As a rule, the wound of entrance is smaller than the wound of exit.

The **wound of entrance** is modified by the manner in which the missile comes in contact with the surface of the body. Changes of position with reference to the long axis in the case of the modern projectile cause the latter

to strike more or less sideways, this "**cross-hit**" causing a wound which differs materially from the small and smooth-edged aperture present when the intact ball strikes with its long axis directly at right angles to the surface. Cross-hits are the result either of the striking of the bullet on some object, such as a tree branch, stone, etc. (ricochet shots), or of its passing through several different media, or through bodies that resist its course more or less strongly. It is therefore apparent that a ricochet shot, if it retains sufficient energy, may do a greater amount of damage than if it had struck in its long

Fig. 28.—Bullet Wound in a Japanese Soldier Received while Lying Down. Photographed after the battle of Liao-yang. A furrow is made in the upper arm and a wound of entrance and exit in the forearm.

diameter. Usually, however, the greater part of the velocity of the missile is lost either by its striking the object on which it ricochetted, or by the greater resistance which the air affords to its passage in its changed position, or by both, and, in addition, the influence of rotation imparted to it by the rifling in the barrel of the arm is lost; the result is that the shot does much less damage than if projected from the same distance without meeting resisting or deflecting bodies on the way and striking in its long diameter.

The wound of exit is increased in size by the tissues driven out with the ball (fragments of bone, portions of muscular tissue, etc.), by the alterations in the direction of the long axis which almost invariably occur and which, when considerable, the power of rotation still being retained, may cause extensive destruction of both bone and soft parts, as well as by deformations of the projectile itself. Variations in the size and shape of the wound of exit also depend on the elasticity and mobility of the part. In organs in which

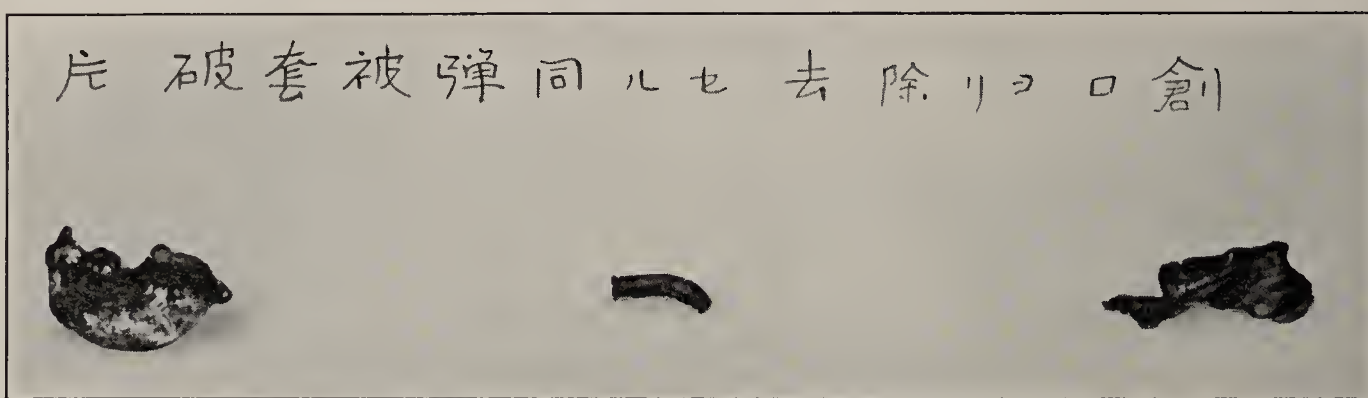

Fig. 29.—Fragments of Mantles Removed from Bullet Wounds (after a photograph from the Medical Department of the Japanese Army).

there is considerable fluid, such as the brain, the heart, the stomach and intestines, the hydrodynamic pressure effect influences the action of the projectile in a marked degree; this effect serves also to explain the radiating concussion or explosive action of projectiles on the tissues in general. The hydrodynamic theory rests on the incompressibility of water and the resulting narrowing of the space through which the transfer of pressure in all

Fig. 30.—Bullet Wound Received by a Japanese Soldier at the Battle of Liao-yang. The shot struck at the range of about 500 yards while the soldier was kneeling. The wound of entrance is about normal in size; the wound of exit is very large and illustrates the destructive effects of the modern projectile at short range. The bone was broken in this case.

directions takes place. The more fluid present in the tissues or organs struck and the shorter the distance at which the shot is fired, the more intense the effect. For instance, a shot at close range may almost completely empty the skull of its contents. In addition to the increase in the effect due to increase in the fluid present and the velocity of the projectile, increase in the caliber and deformation of the latter heightens the damaging effects.

Experiments show that an 8 mm. steel-mantled projectile at 100 meters gives a hydrodynamic pressure of 6.4 atmospheres, while a projectile of 11 mm. at the same distance gives a pressure of 8 atmospheres (Kikuzi).

Deformations of modern projectiles occurring after they enter the body are due exclusively to impact against bone; in wounds of soft parts alone the form of the missile is not altered. In 4.5 per cent of all hits deformation takes place (Coler and Schjerning). A much larger proportion of hits of bone than the above percentage represents, however, actually takes place. In certain parts of bone which are harder than others, such, for instance, as the crest of the tibia, the linea aspera femoris, etc., more deformity of the missile takes place, while bullets lodged in the epiphyses remain comparatively intact.

Fig. 31.—Bullet Wound Received by a Japanese Soldier at the Battle of Liao-yang.

The shot was received at a range of between 700 and 800 yards while the soldier was kneeling. The diameter of the wound of exit as shown is 3¼ inches. The bone was shattered. The wound of entrance at the back of the arm is circular.

The extent of the injury is in direct proportion to the deformation of the bullet. Wherever there is marked shattering of the projectile, there is extensive destruction of bone and a correspondingly large wound of exit. When mushrooming of the modern projectile takes place as the result of disturbances of the mantle, the effects are in no way less than the wounds made by the old-time leaden mushroomed bullet.

The soft tissues with which firearm projectiles come in contact are often greatly diminished in vitality, and more or less sloughing is likely to occur. In addition to this, their repair may be interfered with by infectious material carried in by the bullet, as well as by the presence of foreign bodies. In injuries of long bones, in case the diaphysis is struck, even at ranges of from 1500 to 2000 meters, there is a shattering of the bone as a constant effect. On the other hand, smooth bullet canals are found in the epiphyses even at as short a range as 200 meters (Coler and Schjerning). The claims made that the modern small-bore high-velocity missile is a more humane weapon than the old large-caliber rifle with its bare leaden bullet, as based on the experiments of Bruns and Habert, are not borne out by the observations of Coler and Schjerning. The explanation of this discrepancy seems to lie in the fact that the former experimenters, in order to overcome the difficulties inherent in making experimental shots at long range, shortened the distance and proportionately reduced the

charges, thereby reducing the rotatory velocity of the projectile. It may be confidently stated, however, that in the case of injuries of the soft parts alone the advantages are altogether in favor of the modern arm provided its projectile strikes the body with the mantle or jacket intact. Under these circumstances, and in the absence of injury of the bone, smaller wounds of entrance and exit are made and less damage to the soft parts results.

When but one aperture exists, it is fair to presume that the ball remains in the body. The presence of two openings, however, does not necessarily mean that the bullet has made its exit; only a fragment thereof may have escaped, or two shots may have been discharged from different directions, both projectiles remaining in the body. One ball may produce several wounds of entrance and exit, as in the case of a gunshot wound of the arm and chest, or of a flexed limb, or of both lower extremities struck by the same missile, the latter passing through one and lodging in the other. The missile may graze one part of an extremity, making a furrow, and penetrate or perforate another (Fig. 28). Fragments of mantle torn from the projectile may remain in the tissues, the projectile itself escaping (Fig. 29). The circumstance of fracture of the bone adds greatly to the destructive effects of the shot, not only on account of the radiating concussion (explosive effect) of the arrested bullet, but also on account of the tearing and mangling of the tissues from the deformation which the bullet undergoes and from the disturbing influences of the bone fragments. These sometimes occur in a most extraordinary degree when the shaft of the bone is struck, but in a less degree when the epiphysis is the part injured (Figs. 30 and 31). With loss of velocity and of rotatory force before striking, such as occurs at long range, or at a shorter range in a ricochet shot, the bullet may strike directly on a long bone, as, for instance, the tibia, and lodge in the limb, the bone escaping fracture. If to this are added the effects of a deformed bullet, the conditions present, as shown in figure 32, will obtain. A bullet that has ricochetted and become altered in shape by impact against the object which deflects it from its course, and finally strikes as a cross-hit, will inflict such an injury as that shown in figure 33.

Fig. 32.—Bullet Wound of the Leg Received by a Japanese Soldier at the Battle of Liao-yang.

The wound of entrance as shown is 1¼ inches long and ¾ of an inch wide. The wound shows the usual appearance of a cross-hit (querschläger) from a ricochet shot with deformation of the bullet.

In an engagement in which both rifle projectiles and shrapnel bullets are employed it is sometimes difficult to determine which wounds are inflicted by the latter and which by the former, especially under circumstances where

the best opportunities are afforded for ricochet shots, namely, with the men on the firing-line either kneeling or lying down (compare Figs. 34 and 35).

The Symptoms of Gunshot Wounds.—The more or less constant symptoms include (1) pain; (2) shock; (3) primary hemorrhage. The occasional symptoms are (1) lodgment of the bullet; (2) powder burns; (3) multiplicity of wounds.

The symptom **pain** is an exceedingly variable one. Its intensity depends on the part struck and the circumstances under which the injury is received. Only the most vague recollection of the amount of pain suffered at the moment of being struck is recalled if the injury is inflicted during periods of excitement, as in a battle or in a duel. A condition of local anesthesia may be present about the injured parts.

Fig. 33.—Bullet Wound. Japanese Soldier Wounded at the Battle of Liao-yang.

The soldier was shot at the range of about 200 yards while kneeling. The large wound of entrance suggests that the bullet was deformed before striking, or that it struck as a cross-hit.

More or less **shock** is usually present. This, even in the case of the modern projectile, is usually sufficient to disable the injured one, in spite of the assertion to the contrary so frequently made. The drawn or anxious facial expression is a fairly good index of the gravity of the shock present.

The symptom of **primary hemorrhage,** particularly of the internal variety, may be sufficient to threaten life. In all probability the majority of deaths on the field of battle are due to injuries of blood-vessels in the interior of the trunk. Of fatal external hemorrhage or that which is accessible to the surgeon, and which, seen in time, may be arrested, such as occurs in injuries of the brachial and femoral arteries, the instances are rare (Longmore, 3 per cent; Otis, 0.05 per cent). Aside from the two classes of cases mentioned, in which death may take place at once, the primary hemorrhage from a gunshot wound is rather unimportant. Even when vessels of considerable size are injured by the small-caliber projectile the hemorrhage tends to spontaneous arrest.

The occurrence of **secondary hemorrhage** may be due to some general cause, such as hemophilia, or the presence of constitutional conditions due to prolonged campaigning (scurvy, anemia, etc.) in military practice. More frequently, however, it is due to local causes, among which may be mentioned ulceration or the sloughing of the coats of a vessel from injury of the vessel, this injury involving only its outer coat, the remainder of the vessel giving way

several hours or days later. In former times it was most frequently due to the supervention of septic arteritis in a suppurating bullet track. It may be due to the continued pressure of a lodged projectile, or of a fragment of a projectile or bone, the sharp or ragged edge of which in time causes erosion.

The **lodgment of the missile** occurs with much less frequency in the case of high-velocity small-caliber projectiles than in the old-fashioned, large, smooth-bore guns, and in the pistol-ball wounds of civil life. A missile from a modern small-caliber rifle seldom lodges in the tissues except when fired at long range, or when it meets with intervening objects which retard its flight and lessen its velocity.

The presence of **powder burns** is observed in gunshot injuries occurring at short range and on exposed portions of the body, when the old-fashioned black powder is used. When the wound is inflicted by a revolver, the "powder brand" will bear a rather constant relation to the wound, according to

Fig. 34.—Shrapnel Bullet Wound, Received by a Japanese Soldier at the Battle of Liao-yang.
The wound of exit, 6 inches long by 4 inches wide, is shown in the illustration. The bone was shattered.

the position of the hammer of the weapon when the latter is fired; these two will correspond to each other (Fish). The degree of powder burn will be modified by the distance; a relatively short range will result in superficial burning of the tissues, and a range sufficiently long to enable the parts to escape the flame of the burning powder may yet be sufficiently close to permit grains of unburned powder to lodge in and beneath the skin, causing tattoo marks. These grains of powder may be the means of conveying septic infection, particularly tetanus and malignant edema. The powder brand will be absent in the case of smokeless powder.

The subject of **multiplicity of wounds** has already been referred to (*vide supra*). Multiple wounds occur much more frequently since the introduction of the modern small-bore rifle, and depend on the increased velocity and high penetration of projectiles from this class of firearms. The arms and chest seem to be involved most frequently in simultaneously inflicted multiple

wounds. Either the upper or the lower extremity, when flexed, offers opportunity for the occurrence of multiple wounds from a single missile as a primary complication.

The question of **infection of a gunshot wound** is of special importance. That this may occur through the medium of an infected bullet has been placed beyond dispute by the classic experiments of La Garde, of the United States Army. That all bullets are not infected is true ; it is equally true that all infected bullets do not give rise to suppuration. In the case of the latter the question is simply one of the relations existing between the virulence of the infecting microorganism on the one hand, and the vital resistance of the patient on the other. The infection from clothing, portions of which may be carried in by the bullet, is of greater importance, since it is far more likely to occur than infection from the bullet. Yet even this method of infection is not so common as would be supposed. Meddlesome fingering and probing, even under presumably aseptic conditions, are far more frequently responsible for subsequent suppuration in gunshot wounds than is either the bullet or the pieces of clothing carried into the wound.

Fig. 35.—Bullet Wound Received at the Range of between 600 and 700 Yards while the Soldier was Lying.

The illustration shows the wound of exit 3¾ inches long by 2 inches wide (from a photograph taken under the auspices of the Japanese Army Medical Department after the battle of Liao-yang).

Diagnosis.—The character of the wound of entrance, as well as of the wound of exit, if such is present, will settle the question of the infliction of the injury by a projectile from a firearm. Difficulty will not infrequently be experienced, however, in determining the character of the missile, its caliber, etc. The typic small and clean-cut wound of entrance results when the angle of incidence with the surface is a right angle. More or less pronounced deviations from this are observed with variations in the angle of incidence, extension of the range, and reduction of the residual velocity of the projectile from ricochet. Still more decided departures from the normal aperture of entrance are observed as the result of deformations of the bullet from striking hard substances, such as rocks, etc. In the case of a spheric bullet the wound of exit is larger than the wound of entrance, for the reason that the explosive effect which the invaded tissues manifest as a result of the hydrodynamic force initiated by the invading missile forces the overlying integ-

ument away from the supporting structures beneath, as the pressure takes place from within outward, and an irregularly shaped and larger opening results. When the injury is caused by the cylindroconoidal or the cylindro-ogival projectile of moderate size, and this pursues a normal flight with practically undiminished residual velocity and encounters soft tissues only, passing through the latter almost unimpeded, it may be difficult to distinguish the wound of exit from that of entrance. Departures from these conditions, however, will give rise to varying appearances. Slight ragged and radiating slits from the margins are due either to the escape of small fragments of bone, of fragments of the mantle and lead kernel of the bullet, or to the loss of support beneath the skin. Or a wound several times as large as the wound of entrance may be present, signifying the occurrence of a bone lesion. Differences in appearance between the wound of entrance and the wound of exit can be more easily recognized if the wounds are examined early; later on these differences are more or less obscured by the swelling.

Indiscriminate probing is to be strongly condemned. Instances are few and far between in which the use of the probe is justified prior to a most careful and thorough aseptic preparation. The information thus gained cannot compensate for the risk of conveying infection from the superficial to the deeper portions of the wound, or of spreading infection that has been already conveyed. Fluoroscopy and skiagraphy with the Röntgen ray have practically replaced all other methods of diagnosing the location of lodged bullets and the extent of damage inflicted on osseous structures.

Prognosis.—This will depend on (1) the parts of the body traversed by the projectile and involved in the injury; (2) the primary destructive effects; (3) the promptness with which early assistance can be given and the subsequent care of the case; (4) the type of arm employed.

1. It is estimated that of every 1000 casualties occurring in warfare, there are about 200 deaths on the field; and of the remaining 800, about 110 are wounds of the head, face, and neck; 154 of the chest, abdomen, and pelvis; 252 of the upper extremities, and 285 of the lower extremities (Longmore). Gunshot wounds of the head, large vessels, spine, and viscera are the most serious.

2. The circumstances governing the destructive effects of projectiles have already been dwelt on. In further estimating the probable effects in the individual case the possible deformation of the bullet is of great importance. Some missiles designed for hunting purposes (express bullets) are purposely made to flatten or mushroom on impact, causing extensive mutilation of tissue. This object is effected by omitting the usual mantle or jacket covering of the lead core at the point or nose of the bullet. The same condition is obtained by tampering with the bullet, removing in part the mantle or covering therefrom. The favorite method of accomplishing this among soldiers is to grind away the point of the bullet by means of a rough stone. It is needless to say that this is a murderous practice, and opposed to international agreement as expressed at the Hague conference in 1899. The possibilities of a ricochet shot and consequent deformation from this cause are also to be taken into account.

3. The promptness with which early assistance can be given and the thoroughness of the subsequent care of the case are important factors in estimat-

ing the prognosis of gunshot wounds. In civil life the hospital surgeon can usually control conditions that are ideal in the care of gunshot wounds. In military practice the exigencies of active service make such demands on the surgeon as to render it impossible in most instances for him to do more at first than to apply a first-aid packet to an infected wound, and even this is most frequently done by a hospital corps man or the wounded man's "bunkie." In the subsequent treatment the exigencies of military life require the movement of the wounded so often that they are robbed of the necessary rest, and maintenance of aseptic conditions so essential to the best results is well-nigh an impossibility.

4. The type of arm employed governs the prognosis to a considerable extent. It is unquestionably true that with improvements in the efficiency of firearms there has resulted a lower mortality, both immediate and remote. The very conditions that secure a higher velocity and longer range, likewise assure, on the whole, a more humane weapon, namely, smaller caliber, higher expansive character of the gases from exploded smokeless powder, and, above all, the armored or jacketed projectile. While it is true, as previously stated, that even with all of these favorable conditions present the most terrific destruction may occur, it is also true that the reverse of these conditions favors still more destructive effects.

Complications of Gunshot Wounds.—These are such as relate to wounds in general, and embrace inflammations, gangrene, secondary hemorrhage, aneurism, hospital gangrene, pyemia, tetanus, erysipelas, etc. (see Acute Wound Diseases). In recent years these complications have become quite exceptional in their occurrence. (For gunshot injuries of separate structures see individual structures, and for gunshot injuries of regions see Regional Surgery, Vol. II.)

The General Treatment of Gunshot Wounds.—In simple uncomplicated gunshot wounds a sterile dressing and rest in the recumbent position usually fulfil all the indications. In military practice, before going into battle provision for the occurrence and the immediate protection of gunshot wounds is made by furnishing each soldier with a first-aid dressing consisting of antiseptic compresses protected by oiled paper, and bandages and safety-pins for securing these in position. This dressing is applied either by the wounded man himself, or, if the wound is in a part of the body which makes this impossible, by a member of the hospital corps, an officer or a comrade, either on the spot or at the dressing station; the case is frequently not seen by a medical officer until hours, and sometimes days, afterward. The most that can be said of the first-aid dressing is that, when properly applied, which is not often the case, it serves to protect the parts against further infection. Suppurative conditions, when they occur, are to be treated on general principles. Every effort must be made, in military hospitals particularly, to keep down the number of suppurative cases as much as possible, since sepsis, under the strenuous conditions of active military service, tends to spread with ever-increasing virulence.

The question of the **removal of lodged bullets** is an important one. In military practice the cases are rare in which it is necessary to remove the bullet at once, and even in civil practice it happens frequently that more harm may be done by persisting in an effort at removal than by permitting the

missile to remain. If time and environment permit, there is no objection to the removal of a bullet that is immediately beneath the skin, provided aseptic precautions can be rigorously enforced; on the other hand, neither the surgeon in charge of an ambulance in civil life, nor those engaged at the dressing stations in military service, should attempt the removal of lodged bullets. A bullet superficially situated and easily felt may be removed at the field hospital; the removal of those deeply situated and not definitely located should not be attempted until a field hospital on the line of communication or a base hospital is reached, where the *x*-ray apparatus can be employed to assist in the search.

Lodged projectiles that cause pain by pressure on a nerve-trunk, those that interfere with the function of a part, and those that lie at the bottom of an infected bullet track should be removed. Irregularly shaped fragments of bullets, pieces of shell and of the covering or mantles of projectiles, unless these lie in inaccessible regions, should be removed.

Attention has been called to the occurrence of **plumbism** as a result of lodged leaden missiles (Nimier and Laval). This occurs with greater frequency in case of the lodgment of small shot, or of the separation of the bullet into fragments, particularly where these lodge beneath the periosteum or in the cancellous tissues, or in the medullary cavity of bones. The symptoms disappear on the removal of the missiles. Lead intoxication, even in civil practice, is a very rare sequence of the lodgment of unprotected bullets; it will be rarer in the future in military practice, on account of the almost universal adoption of the mantled or protected bullet, and the infrequency with which this lodges in the tissues.

SECTION IV

ACUTE WOUND DISEASES

ERYSIPELAS

Erysipelas is an infectious progressive inflammation of the skin, with a clearly defined and circumscribed area. It is characterized by a redness of the surface, varying with the intensity of the inflammation, as well as with the location of the disease. In the scalp, the edges of the wound may be pale, with some serous infiltration at the commencement. Its circumscribed margin distinguishes it from phlegmonous inflammation of the subcutaneous connective tissue, in which the redness gradually merges into the surrounding healthy parts. Where lymphangitis follows erysipelas, its well-defined edges are wanting, but in the former, red lines or stripes will be present corresponding to the lymph-vessels.

Increased heat and swelling are present. The former is demonstrable by means of the surface thermometer; the latter is inconsiderable, and ordinarily scarcely perceptible, except in localities where serous infiltration occurs (scalp, etc.). A burning sensation rather than pain is complained of.

The disease, in its progress, varies as to rapidity. In advancing, the margin does not, as a rule, maintain a symmetric contour, but projections occur here and there, giving it an irregular outline. Locality seems to influence the more or less rapid progress of the disease. The direction taken is generally that of the lymphatic current, though exceptions to this are numerous.

In **erysipelas bullosum** there occurs a profuse exudation of colored serum in the rete Malpighii, with the formation of vesicles. These occur after the stage of redness, about the second or the third day, and are not unlike the blisters following a burn. Suppuration may occur in these.

Phlegmonous erysipelas is characterized by a suppurative process in the subcutaneous connective tissue, coincident with the inflammation of the skin. It constitutes a severe form of the disease.

Gangrenous Erysipelas.—All the other forms may culminate in this, but the phlegmonous variety is particularly liable to merge into the gangrenous variety.

Blisters form from obliteration of the nutritive vessels, and brownish-red spots, which afterward change to black, appear. Necrosis of tissue and putrefactive changes soon develop. If phlegmonous cellulitis has not preceded the gangrenous form, it rapidly develops after the appearance of this form. The gangrenous condition shows the same tendency to spread as the others.

In certain **erratic** or **wandering** forms, the disease spreads irrespective of direct continuity of tissue, attacking remote portions of the body either simultaneously or successively.

Clinical Course.—A rapid and continuous rise of temperature occurs.

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A chill, except in very mild cases, usually precedes the disease development. Sweating is rare; a dry condition of the surface is present.

Nausea and vomiting generally follow the chill. Except in very severe cases, these, as well as the chill, are not repeated. Anorexia is present. Diarrhea is rare; constipation is the rule. The temperature curve is irregular but follows more or less the progress of the disease, as it attacks new tissue. Its duration is, on an average, about one week. Low morning temperature denotes the subsidence of the attack. High temperature both morning and evening gives a more favorable prognosis than high evening temperature alone.

Complications.—Albuminuria to a moderate extent sometimes occurs, though it soon disappears. Bronchitis is a not infrequent complication, but pneumonia is rare. The serous membrane may be attacked, particularly the meninges, in erysipelas of the scalp. Pleuritis may follow erysipelas of the chest walls, peritonitis that of the abdominal surface, and synovitis erysipelas about joints. The mucous membranes may be attacked, with submucous infiltration, particularly the nasal and faucial cavities in erysipelas of the face.

Etiology.—The idiopathic origin of erysipelas has long been disproved. "Catching cold" and mental emotion are no longer considered factors in the causation of the disease. Erysipelas is **infectious** in origin, **contagious** in character, and both endemic and epidemic in its occurrence. It is most frequent in low, swampy localities, less so in elevated and dry situations. It is more prevalent in the months of December, February, and March.

The contagiousness of the disease was known long prior to the discovery of the bacterial origin. Instruments, the surgeon's fingers, bed and bedding were known to convey the disease. Micrococci were found by both Hueter and Recklinghausen in blood taken from erysipelas patients and from portions of skin removed postmortem, but it was not until methods of obtaining pure cultures were introduced that ordinary pus cocci were eliminated and the essential and characteristic organism, the Streptococcus pyogenes (see page 27), was isolated and demonstrated (1884). This demonstration was confirmed by successful inoculation experiments.

Predisposition to Erysipelas.—This varies, as in all infectious diseases. It may be local or individual. Certain localities, notably the scalp, are especially predisposed to its occurrence (see page 431). Operations for the removal of lipomas are also followed, in a certain proportion of cases, by erysipelas. The fatty tissue itself is not particularly liable to it, but the thin and atrophic skin covering lipomas seems to invite an attack.

The predisposition of individuals is well known. It is more frequently observed in weak persons with tender skins. For this reason blonds are more liable to be attacked than brunettes. In these, slight abrasions of the epidermis, and even normal furrows of the skin, as well as the open mouths of sebaceous follicles, may be the seat of invasion by the infectious agent. It is very doubtful if erysipelas can occur without invasion of the streptococcus from without.

Except for the endemic occurrence of erysipelas, careful and conscientious application of aseptic precautions will prevent its development as one of the wound sequels. Its epidemic occurrence should be taken into

account, and, in its presence, operations, particularly about the head and neck, should be postponed.

Erysipelas occurring in patients who are already debilitated from large losses of blood or other causes following major operations is of serious import. This is particularly true of the suppurative or phlegmonous form.

In certain cases of inoperable sarcoma the neoplasm has been inoculated with Streptococcus pyogenes (P. Bruns, W. B. Coley). While encouraging results have been obtained by the use of the toxic products of Streptococcus erysipelatis, mixed with those of Bacillus prodigiosus, in the hands of the originators of the method, the latter may be said to be still on trial. On the other hand, death has followed the experiment (Janicke, Neisser).

The disease known as elephantiasis arabum is said to have its origin in repeated attacks of erysipelas (see page 84).

The erratic or wandering form of the disease furnishes, as a rule, a better prognosis than the other varieties.

Treatment.—In the prevention of the disease the most rigid details of asepsis are requisite (see page 48). The necessity for this should impress itself on the surgeon's mind, particularly if he is compelled to dress non-infected wounds after being in contact with a patient who has erysipelas. All dressings that have been used should be burned, and towels, sheets, blankets, etc., subjected to at least the boiling process in the laundry. Instruments should undergo the most rigid sterilization, and the free and liberal use of soap, hot water, and sublimate or carbolic solution on the part of the attendants should be enforced.

Prior to the introduction of antiseptics into practice, the surgeon was almost helpless in the face of this formidable disease. Its rational treatment began with Lücke's recommendation of the local use of turpentin and Hueter's use of tar and of the subcutaneous injection of carbolic acid at the margin of the disease, at which point the streptococci proliferate most rapidly. The carbolic injections may be replaced by sublimate 1 : 5000, or salicylic acid solutions (Peterson). Multiple scarifications and incisions through the skin at the margin of the erysipelatous zone (Kraske, Riedel), with the subsequent use of a 5 per cent carbolic or a 1 : 1000 sublimate solution (Lauenstein) in the shape of compresses, are valuable measures. The addition of tincture of opium in the proportion of two ounces to the pint to the antiseptic solution is of advantage. These solutions should be applied warm upon compresses either with or without the preliminary incision of the skin, and the compresses covered with oiled silk. Where danger is to be apprehended from carbolic acid poisoning creolin may be substituted.

The fever should be combated by the usual antipyretic measures. Luke-warm baths and the cold pack may be necessary in extremely high temperatures; quinin is useful in ordinary cases. Supporting measures should be employed and nourishing but easily digested food allowed.

ERYSIPELOID

Rosenbach has described, under this name, a form of infectious dermatitis which is sometimes observed in persons, butchers, cooks, etc., who have occasion to handle dead animals. The point of primary infection is some

minute abrasion of the epidermis, from which point a bluish-red infiltration gradually spreads, generally toward the trunk. The infection travels very slowly, occupying a week in passing from the finger-tip to the metacarpophalangeal joint. The margin of the patch maintains the original bluish-red infiltration appearance, while the point originally infected and its immediate surroundings return to the normal.

There are no constitutional disturbances; the disease is a purely local affair and has a self-limited course, lasting two or three weeks. The inflamed parts give rise to some burning, smarting sensations. The disease is of interest to the surgeon mainly because of the liability to mistake it for erysipelas.

The etiologic factor in the disease is some specific infecting agent, supposed to be one of the thread-forming microbes.

No treatment is necessary. The disease tends intrinsically to recovery.

HOSPITAL GANGRENE

This consists of a septic inflammation of the granulating surface of wounds in which there is a coagulative necrosis of the upper layer of the granulations, due to either an imperfect development of the vessels or an obstruction of their lumina by septic inflammatory processes, or a coagulation of fibrin in a layer of exuded blood-plasma. The resulting pellicle occurs in the shape of a firmly adherent thin parchment-like layer resembling diphtheritic deposits on mucous membranes (**"wound diphtheria,"** Hueter). The disease begins with small pointlike ecchymoses in the granulations; the latter turn to a dirty grayish-brown color. Fusion of the granulations occurs, minute abscesses form, and a true ulcerative process may be initiated. In the pulpy variety a profuse exudation occurs from the newly formed blood-vessels in the granulations. The latter become greatly swollen and grayish-white, rising above the level of the skin like a mass of sponge. Finally these may culminate in the **gangrenous** form. The inflamed structures become necrotic, putrefaction sets in, and sometimes the most rapid advance of the disease takes place. The destruction of the granulations opens up the way for renewed infection and the rapid breaking down of the tissues furnishes the bacterial agents of infection in large numbers.

Clinical Course.—All of these forms may be observed on the same granulating surface. Slight hemorrhages may be present at one point, suppurative destruction of the granulations at another, and a spongy elevation may appear at a third. Finally a gangrenous condition may supervene. As long as the granulations remain intact no lymph-vessels are opened, and constitutional symptoms are absent. With the destruction of the granulations, bacterial infection occurs and febrile symptoms appear. This may occur within the first twenty-four hours. The rise of temperature, although not high, is accompanied by a disproportionate depression of the vital powers. In this respect the disease resembles diphtheria of mucous membrane. The temperature, even in markedly septic and gravely depressed conditions, may remain normal or even become subnormal.

Prognosis.—This is grave in proportion to the amount of depression and the extent of the local disturbances. In the gangrenous variety large vessels may be opened and fatal hemorrhage follow. Invasion of large

serous cavities or of joints by the ulceration or gangrenous process involves great danger to life. Pyemia may develop.

Etiology.—The affection arises from infection of the granulating surface, either from contact with unclean dressings or from the air. In former times the disease occurred especially in military hospitals, from want of care in the selection and application of dressings; hence it was known as hospital gangrene. It occurs, however, in private as well as in hospital practice, if care is not exercised in wound dressing. The mass of microorganisms found locally and in the blood of the patient fixes the bacterial origin of the disease; a specific germ, however, has not yet been discovered. It is probable that the gangrene which occurs in wounds may be caused by more than one microorganism. In two instances of rapid gangrene occurring in my service in St. Mary's Hospital, Bacillus pyocyaneus was isolated in pure culture from tissues at some distance from the gangrenous area.

Treatment.—This is to be conducted on the principles of asepsis and antisepsis, the former method to be used in the prevention, the latter in the cure. The use of carbolic moist compresses is indicated; these are to be renewed at least as often as once in six hours. A 5 per cent solution should be employed. At each change of dressing the softened granulations should be curetted away. In more severe cases an application of zinc chlorid, from 10 to 20 per cent in strength, is to be used, well rubbed in. In the gangrenous variety recourse should be had to the thermocautery for the purpose of completely destroying the infected surface and its infectious agents. The effect of the application of the actual cautery to these gangrenous conditions of a wound is sometimes marvelous. Acid escharotics (chromic acid, nitric acid, etc.) are to be preferred to alkaline ones, such as caustic potash, etc., for the reason that the former have a more decidedly antibacterial effect. Hydrogen dioxid is useful in aiding the destruction of the dead organic matter (Warren). Iodoform gauze saturated with hydrogen dioxid should be packed in all the recesses of the wound.

MALIGNANT EDEMA (Pirogoff); ACUTE PURULENT EDEMA

This form of gangrenous inflammation, sometimes known as **gangrène foudroyante** (Maisonneuve), is a most dangerous affection. It sometimes accompanies severe injuries of bone and extensive contusions of soft parts, as well as less severe injuries, insect stings, etc. It is characterized by rapidly advancing septic inflammation of the subcutaneous connective tissue and the intermuscular planes, with rapid putrid decomposition and the formation of gases. The skin assumes a dirty brownish-red color, with distended veins filled with stagnating blood. The tissues are edematous and infiltrated with gases, which give rise to a crackling sensation on palpation. A thin ichorous discharge occurs from the wound; this can also be pressed out of the edematous tissues into the wound cavity. The neighboring lymphatic glands become greatly swollen, and the general condition of the patient shows that the products of putrefaction are being rapidly disseminated through the system by the medium of the lymph-channels. The temperature rises rapidly; remission, as a rule, does not occur. Typhoid symptoms, such as blunted sensorium, dry tongue, tough, fetid mucus in the roof of the mouth, rapid and feeble pulse, and dilated pupils are present. In other cases jactitation

and delirium, followed by coma and involuntary evacuation of the contents of the bladder and rectum, precede the fatal issue. The patient is too apathetic to complain of either pain or thirst. The symptoms may supervene within a few hours of the injury, and death may occur in from forty-eight hours to three or four days, an entire extremity in the meanwhile becoming involved in the disease.

Etiology.—The affection is essentially the result of a putrefactive process and is of undoubted bacterial origin. It probably depends on a bacillus found almost universally in common garden earth, Bacillus oedematis maligni (see page 30).

Treatment.—Since the introduction of antiseptic methods of treatment this excessively dangerous disease is of much less frequency than heretofore. A most vigorous antiseptic course must be followed. While the use of free and extensive incisions may be of some service in mild cases, these cases are so few compared with those overwhelmingly malignant, that amputation will be the rule, rather than the exception. This should be performed promptly, and as high up as possible.

INFECTIOUS EMPHYSEMA

This is an emphysematous condition of the tissues of the body and is due to the presence of Bacillus aerogenes capsulatus. The microorganisms may gain entrance through an accidental or an operation wound and infect the surrounding structures. Their presence is followed by the formation of gas, which is marked by the occurrence of swelling and a crackling sensation on palpation. In this class of cases there is usually but moderate constitutional disturbance. In more severe cases the viscera are filled with gas bullae and the blood with bubbles. In these cases it is supposed that the infection gains entrance from a perforative lesion of the intestinal canal.

Treatment.—When the emphysema appears in the neighborhood of a wound the latter is to be considered as the starting-point of the infection and treated accordingly. In mild cases when the emphysematous condition is limited and shows no disposition to spread, and when constitutional symptoms are absent, simple watching is all that is required. Upon the supervention of symptoms of extension, or of constitutional disturbance, however, the treatment for an infected wound is to be instituted immediately. If the emphysema still persists or increases, in addition to thorough disinfection of the wound, incisions are to be made in the infected area and wet sublimate gauze is to be employed as a packing, compresses of this being applied as well. The mild cases may recover without the reopening of the wound, and even the more severe forms, with simple yet efficient antiseptic treatment of the wound.

SEPTICEMIA

This is a form of systemic poisoning of bacterial origin in which living bacteria are found in the blood. While they are deposited in many cases in the liver, spleen, and kidneys, the disease differs, in typic examples, from pyemia, in that septic inflammation and the formation of abscesses in these organs do not occur. When the symptoms of sepsis as well as those of pyemia are present the term **septicopyemia** is used.

Clinical Course.—The disease is ushered in by a rise of temperature, this varying from 101° to 105° F. even within the first few days after the injury. The occurrence of a well-marked chill is not common and is not repeated if it does occur, the disease differing in this respect from pyemia. The pulse-rate is increased to 120 or more, and a remarkable condition of indifference and lassitude is present. The tongue is dry and leather-like and is protruded with a hesitating and trembling movement over the parched lips. The skin is hot and dry, and is a dirty brownish color. In severe cases a pale yellowish hue of the skin is present, with dark purplish-red spots (petechiae). These point to a disintegration of the blood; the blood-corpuscles perish and the blood pigment is diffused into the tissue (hematogenous icterus). The walls of the vessels also undergo changes from the influences of the ptomains, and a hemorrhagic predisposition is present. The wound itself undergoes characteristic changes. The edges become shrunken, the granulations become flabby and turn to a dirty gray, and thin and offensive discharge occurs. Anorexia is present; constipation is the rule, though in the severe forms profuse and not infrequently bloody diarrheic discharges occur. The respirations are rapid and superficial.

The disease may last from five to fourteen days. Improvement is announced by remissions of the fever, preceded by a more or less pronounced perspiration, the clearing up of the intellect and deeper and less rapid respirations. The wound assumes a healthier aspect and granulations spring up. In fatal cases the apathetic state passes into coma, the temperature may drop below the normal, and the pulse becomes extremely rapid and feeble.

Pathologic Anatomy.—Examination of the blood shows the destructive effects of the bacterial infection on its corpuscular elements. The contents of the large venous trunks show incomplete coagulation; the blood is very dark, and tarlike. An acid reaction is sometimes observed.

The spleen, liver, and kidneys are the seat of more or less turgescence. The serous membranes are sometimes more or less covered with ecchymoses and the cavities contain a small amount of brownish-red fluid. The fibrillae of the muscles are the subject of granular degeneration, as shown by microscopic examination. They are a dark-brown color, particularly in the neighborhood of the wound. The condition of the blood is such as to produce rapid decomposition of the body after death.

Etiology.—The disease was formerly regarded as autointoxication from the absorption of the products of a general proliferative process occurring in the wound. Attempts were made to isolate a chemic substance from the wound secretion (sepsin of Bergmann). Inoculation experiments with this, though fatal to the animals, did not reproduce the picture of the disease.

Klebs, in 1871, demonstrated the presence of bacteria in septic wounds. By filtration of the wound-secretion he also showed that the filtered liquid had but a comparatively slight degree of infecting power, while the filtrate itself produced a rapidly fatal febrile condition, thus proving that the disease was one of infection rather than of intoxication. The experiments of Devaine (1872), however, settled the question. Inoculations from one animal to another showed that even the tenth animal died from septicemia.

The question as to the bacterial origin of septicemia was further studied by C. Hueter, whose results, however, were subjected to considerable criticism, though he undoubtedly discovered the presence of bacteria in septicemic animals as well as in man. His observations were confirmed in part by Birch-Hirschfeld and Koch.

While certain microorganisms are found pathogenic to different classes of animals (bacillus of mouse septicemia of Koch, bacillus of hog cholera of Salmon and Smith, the micrococcus of rabbit septicemia, etc.), a separate form has not yet been discovered in man.

Prognosis.—Prior to the antiseptic era, this disease was preeminently a fatal one. Together with pyemic and hospital gangrene, it swept away the great majority of patients who died in the surgical wards of hospitals. At the present time these three diseases are rarely observed, and only then when there has been a neglect to apply, or a failure to maintain the necessary aseptic or antiseptic measures.

Treatment.—In the very beginning of the disease, the changed conditions of the wound and the occurrence of a foul odor will arouse suspicion, and an energetic application of antiseptic treatment will be imperatively demanded. This includes the opening up of the wound, the curetting away of decomposing shreds of sloughing connective tissue, thorough irrigation, and the establishment of counter-openings when necessary for purposes of efficient drainage. The interior of the wound should be well swabbed with a 10 per cent solution of zinc chlorid. When a joint is involved, the medullary tissue is finally invaded, and resection or amputation may have to be resorted to in order to save life. The internal treatment will include the use of quinin and alcoholic stimulants. Oil of turpentin has likewise been recommended. The inhalation of oxygen with the view of utilizing to the greatest extent the function of the red blood-corpuscles still available is indicated.

PYEMIA

This is an infectious wound disease produced by pyogenic organisms and characterized in its course by the invasion of distant tissues of the body by secondary foci of suppuration. The microorganisms are carried into the blood through the lymph-channels (Halban), whence they are distributed to the points where they lodge and proliferate and set up destructive changes.

Isolated cases are observed in which a so-called **spontaneous pyemia (cryptogenic pyemia)** occurs. These either occur from the passage of bacteria through the medium of the follicles of the mucous membrane lining the respiratory or digestive tract, or depend on a minute abrasion of the epidermis, without the development of a distinct local inflammation.

Finally, a mixed infection may occur, the so-called **septicopyemia.** Either condition may precede the other, but the term should not be used to apply to a distinct affection, for such does not exist.

Metastases.—These are found most frequently in the lungs. Abscesses of various sizes are found, usually situated at the periphery. When adjacent to the pleural covering, a pleuritis occurs, which may result in serous, fibrinous, seropurulent, or even purely suppurative exudation. A diffused lobar pneumonic infiltration may take the place of the multiple foci and inclose a single metastatic abscess, or a gangrenous portion of the lung.

Next in frequency the **liver, kidneys,** and **spleen** are the seat of pyemic suppurative foci. The **connective tissue** and **muscles,** particularly the tendinous attachments of the latter, as well as the **heart, brain, eyes,** the **synovial lining of joints,** and the **serous membranes** are attacked. The knee-joint, hip-joint, and elbow-joint are the most frequently attacked. These may be simultaneously or successively invaded, and without due care the joint affection may be mistaken for a rheumatic attack. The serous membrane may be attacked independently of neighboring structures or adjacent organs, as, for instance, tendinous sheaths, or these structures may suffer from extension, as the peritoneum in case of the liver and spleen, the pericardium in the case of the heart, the arachnoid in case of the brain, etc.

Clinical Course.—Usually several days elapse between the reception of the injury and the occurrence of the primary suppuration. The onset of the disease proper occurs several days later. From the date of the injury to the commencement of the pyemic process, therefore, the earliest symptoms will not occur within eight days, and they may be delayed for several weeks. The occurrence of metastases will be marked by a sharp chill, followed by a rise of temperature and local symptoms to indicate the points of secondary suppurative foci. The temperature, though it may reach 105° F., does not rise rapidly. The extent of the fever due to metastases may be masked by the previous existence of a surgical septic fever, or erysipelas. The occurrence of repeated chills and the increase of previously existing fever, which may assume a remittent or even intermittent type, will serve to identify the process when occurring in conjunction with local symptoms, such as cough with physical signs of circumscribed infiltration and softening, in case the lungs are invaded; local pain and tenderness in the case of the liver and spleen; pus in the urine in the case of the kidneys, etc. The disease is most likely to be mistaken for a severe malarial affection; the sweating stage of the latter, however, is absent. The chills may occur coincidentally with each new deposit, and in the commencement of the disease each succeeding suppurative focus furnishes a more or less distinct exacerbation of the febrile symptoms. With the occurrence of a large number of metastases the chills become less frequent, the fever maintains itself at a higher grade, the vital forces give way, and the patient sinks from extreme and rapid asthenia.

Many of the points of deposit may escape discovery altogether, particularly when in deep-seated joints, as the hip. This is due in some degree to the painless character of the suppurative process of the joints in this affection as compared with the process which occurs in traumatic cases.

The other constitutional symptoms are such as obtain generally in febrile affections, including dry skin, the latter assuming a leathery character in cases of long duration, dry tongue, and vexatious thirst.

Etiology.—Clinical observations point to the probability of a specific microorganism for this disease, yet efforts thus far have failed to isolate such. If the bacteria of common suppuration were alone involved in the causation, the disease, it is fair to assume, would be of far greater frequency. It has been asserted that an essential factor in the production of the disease is the absence of a protecting wall of granulation in primary suppurative foci, thrombophlebitis resulting. Even this will not explain its infrequency; such granulation barriers must be very often absent, as, for instance, in whitlow and its

frequent sequel, phlegmonous inflammation of the synovial sheaths of tendons. Yet even in preantiseptic times pyemia rarely followed these rather common conditions. That some specific morbific cause enters from without is rendered probable by the fact that the disease is of rather frequent occurrence in improperly treated and hence suppurating compound fractures, while in acute infectious osteomyelitis it is exceedingly rare. In both instances there is an acute suppurative inflammation and the medullary veins are equally exposed to the invasion of bacterial infection.

The epidemic and endemic occurrence of the disease is to be taken into consideration in discussing its etiology. Its outbreaks in connection with crowded military hospitals in times of war are matters of medical history. There are many reasons for believing that there is a specific poison at work under these circumstances, and that this is capable of being conveyed by the air as well as by contact. It was suggested by Hueter that this poison resides in a special microorganism which possesses peculiarly energetic powers of infection, but which, in its turn, is destroyed by the common pus cocci. Rosenbach, however, concluded after patient observation that Streptococcus pyogenes and Staphylococcus pyogenes aureus produced pyemia.

The metastases are accomplished through the medium of the blood-current, as well as through that of the blood-lymph. When the route is the blood, the lungs suffer mainly. The metastases, under these circumstances, are largely of embolic origin (Virchow). These emboli are infected with bacteria and again produce suppuration at the place of deposit. The loosening of a portion of clot and its migration to the right heart, and thence by way of the pulmonary artery to the respective lung, in case no bacterial infection or pus is likewise transferred, will produce simply a hemorrhagic infarction.

Pyemic foci occur in the **liver, kidney, spleen, muscles,** and **subcutaneous connective tissue;** in fact, the entire capillary area is exposed to infection. Bacteria alone, or carried along by pus-corpuscles, traverse the lymph-vessels and glands, and may pass even through the pulmonary circulation and thus gain access to the arterial current. In this manner the general invasion of joints, pleura, pericardium, and peritoneum is explained.

Prognosis.—The disease once under way, its cure depends on an arrest of the metastases, and the subsequent discharge, resorption, or encapsulation of already existing secondary foci. A pulmonary abscess may discharge into a bronchus; nephritic abscess may empty itself into the pelvis of the kidney and be discharged with the urine; those situated near the surface may make their way through the skin. The joint affections do not always suppurate, and hence resolution may likewise occur. Notwithstanding all these possibilities, recovery from the disease is rare; the affection always tends to a fatal termination.

In proportion as the primary focus of suppuration is small and easily accessible, permitting surgical treatment, will the prognosis be rendered more favorable. The ability of the patient to bear repeated deposits and renewed assaults upon his vital forces will also have a bearing on the prognosis. A condition of "**chronic pyemia**" may finally carry the patient off after a long and painful struggle.

Treatment.—Under careful aseptic and antiseptic management of wounds this disease has almost disappeared. Yet it is occasionally met with, under circumstances beyond the control of the surgeon. The primary focus of suppuration must be at once attacked, in order to prevent further infection. Free incisions and vigorous antiseptic treatment may suffice in mild cases. These failing, if the suppuration is in a limb and important internal organs are not involved, amputation must be performed; extirpation of a suppurating tumor, and extensive incision of phlegmonous areas, are measures not to be considered as too radical when life is so urgently threatened.

Ligation of the larger veins, when these are found to be the seat of thrombi, has been suggested (Klebs); favorable results of this expedient have been reported.

When the joints involved show evidences of suppuration, they should be freely incised, antiseptically irrigated, and drained. Abscesses in the muscular structures and in the parotid gland, which seems particularly liable to the infection, as well as those in the connective tissue, may be easily reached and freely incised. The pericardium may be aspirated (B. F. Westbrook), and even incised and drained; the pleural cavity is capable of free drainage and antiseptic irrigation; the peritoneum may be incised and drained.

In the meanwhile the patient's strength must be supported by every possible means, both dietetic and medicinal. Quinin, or the cinchona preparations, with mineral acids, are useful. Alcoholic stimulants and malt liquors are particularly indicated. Antipyretics of coal-tar origin, such as antipyrin, antifebrin, and phenacetin, should be used cautiously, if at all, on account of their depressing action.

TETANUS

This belongs to the class of wound infectious diseases in which the microbes or their ptomains affect the central nervous system. It is characterized clinically by spasm, either clonic or tonic, of definite muscular groups. Those of mastication (trismus) and of the head and back (opisthotonos) are the most frequently affected.

Clinical Course.—The disease usually commences with some restlessness on the part of the patient, and an anxious or pinched expression of countenance, with elevation of the external angle of the eyes. There is some difficulty in opening the mouth. In speaking, the patient keeps the teeth together on account of the spasm of the masseteric and temporal muscles. The muscles of deglutition next become affected, and finally the muscles of the back of the neck and the extensors of the spine. The opisthotonos which now occurs is characteristic; the body rests on the occiput and heels when the patient is in the dorsal position. The anterior trunk muscles may become affected, producing a position the reverse of opisthotonos, that of emprosthotonos. Contraction of the lateral trunk muscles produces pleurothotonos. More or less rigidity of the affected groups of muscles persists (tonic spasm), though this is increased by paroxysmal convulsive movements (clonic spasm). The symptoms bear a striking resemblance to those of strychnin poisoning.

The slightest peripheral irritation, even a draft of cold air, in severe cases, brings on aggravation of the muscular spasm and most excruciating pain. Respiration is interfered with in proportion to the extent of involvement of

the respiratory muscles. The pains, which are sometimes most excruciatingly severe, usually follow the course of the nerves leading from the spinal cord to the affected muscles. The sensorium generally remains unaffected during the entire course of the disease. A profuse salivary secretion escapes from the mouth through the set teeth. The pulse in acute cases is rapid and feeble, and the temperature rises to 40° or 41° C. (104° to 106° F.). Wunderlich has noted a postmortem temperature of 44.7° C. (112° F.). Profuse sweating is a characteristic symptom.

There is inability to take food and drink. In consequence of this, and of the intense pain and loss of sleep, there is rapid emaciation and loss of strength early in the disease. There is generally more or less cyanosis present, and, the diaphragm becoming involved, a spasm of this suddenly produces death. When death takes place from exhaustion, a profuse and clammy perspiration, coldness of the extremities, and weak, intermittent, and rapid pulse precede the lethal exit, which may occur in some cases in a few days.

In cases which terminate in recovery, the muscles of mastication present more or less stiffness for several weeks, which gradually subsides.

Tetanus neonatorum.—This occurs in infants during the first week following birth. It is almost invariably fatal, and that very shortly after the attack. The point of infection, as a rule, is the umbilicus.

Trismus, associated with paralysis of the facial nerve (E. Rose, 1870), is a peculiar form of trismus following injuries of the head, and particularly of the facial region. It is sometimes called hydrophobic tetanus, from the fact that attempts to swallow bring on the spasms. The prognosis is more favorable than in the other varieties. Rose's trismus may pass into a chronic or typhoid form of the disease, which is followed by death.

Etiology.—The essential cause of tetanus is the Bacillus tetani of Nicolaier (1884), who discovered it in garden earth. Rosenbach demonstrated its existence in the wound secretions of tetanic patients. Sternberg in 1880 produced tetanus in a rabbit by injecting beneath its skin mud from the street gutters of New Orleans. The identity of these bacilli was established in Koch's laboratory (1887). A pure culture was obtained by Kitasato (1889).

The ptomains of the bacillus are undoubtedly the toxic agents acting through the medium of the spinal cord. One of these, isolated from cultures of the microorganism, called "tetanin" (Brieger), injected beneath the skin of animals, produced tetanic convulsions.

Wounds of the hands and feet are said to invite the occurrence of the disease. This is probably due to the greater exposure of these parts to the material containing the infective agent. Extirpation of the thyroid gland has been followed by tetanus (13 cases reported by Weiss). It occurs more frequently after partial than after total extirpation (Billroth), and is said to be due to the increased peripheral irritation caused by the application of a large number of ligatures. The colored races are attacked more frequently than the Caucasian race. The conditions of climate in southern regions favor reproduction of the bacillus. Conditions of soil also favor its cultivation and propagation.

Incubation.—The period of incubation is extremely variable both in the lower animals and in man. This depends on (1) the number of bacilli

introduced (Watson Cheyne); (2) the location of the point of infection and the anatomic characteristics of the surrounding tissues; (3) the capacity of the different tissues to yield the ptomains under the influence of the bacillus. It is also probable that the degree of virulence of the bacillus governs, to a certain extent, both the duration of the stage of incubation and the severity of the attack.

Prognosis.—This will be governed by the type of the disease. The attacks characterized by an early and sudden onset and intense symptoms are more than likely to prove fatal. Later and slow development of the symptoms and a less violent manifestation of the characteristic spasms may end in recovery. If the patient survives beyond the fourteenth day, recovery is the rule and death the exception. Even a chronic state may follow an acute attack; after a period of weeks or more, recovery may take place. Not less than 75 per cent of all cases prove fatal.

Pathologic Anatomy.—The most constant pathologic lesions found are inflammatory softening of the gray substance of the cord and dilatation of the vessels. Hyperemia of the medulla oblongata and spinal cord is always present. An entire absence of gross pathologic changes is characteristic of the disease.

Treatment.—The preventive treatment depends on an antiseptic regimen in connection with all wounds, and the prompt removal of foreign bodies. Punctured wounds of the hands and feet are, as a class, more liable to be followed by tetanus than are incised wounds. As the bacillus of tetanus will not grow in the presence of oxygen, it is evident that a punctured wound quickly closed offers just the conditions appropriate for reproduction of the germ if it has been introduced into the depths of the wound. Wounds of this character, as well as those inflicted by toy pistols, the cartridges of which contain earth, should be laid freely open and thoroughly disinfected by a 1 : 1000 solution of corrosive sublimate and wet dressings of this applied. The efficiency of the sublimate solution is enhanced by the addition of alcohol (see page 60). Equal parts of 95 per cent alcohol and a 1 : 500 solution of sublimate may be employed. This course is imperatively demanded in localities where tetanus is known to follow trivial wounds. Under no circumstances should a small opening be sealed by a dry dressing.

Among the internal remedies employed in the symptomatic treatment of tetanus, Calabar bean, chloral, and opium are to be mentioned. Chloroform is largely used in the South in the hyperacute cases. Of these remedies, Calabar bean is of value in relieving the muscular contractions. It is to be given in doses of from one to one and a half grains of the extract every three or four hours. For subcutaneous use twenty drops of a 1 per cent solution of the extract is to be administered. Chloral acts by diminishing the reflex excitability of the nerve-centers, but it is not a curative agent. It relieves pain, however, and limits the spasms as well as wards off the convulsive attacks. It should be given to the extent of from 100 to 200 grains in twenty-four hours if necessary. It is sometimes thought advantageous to combine it with bromid of potassium. Chloroform may be administered by inhalations when required to relieve the excruciating pains and to relax the contracted muscles. Spasm of the glottis will sometimes prevent its use. Hypodermic injections of morphin every two or three hours have been employed.

Treatment by Tetanus Antitoxin.—Experiments made with the view of establishing in animals immunity from the disease have been carried on, and it has been shown that the blood of animals rendered immune may have the effect, when injected into other animals, not only of rendering these immune, but of curing the disease when it is established. The blood-serum of such animals, when brought in contact with the poison outside the body, destroys its toxic properties (Kitasato, Behring). The horse is usually employed in the production of tetanus antitoxin. The dose of the latter and the frequency of the injection vary with the preparation used, the weight of the individual, and the urgency of the symptoms as well as the improvement noted. In hyperacute cases with a short period of incubation a large dose must be employed. Prophylactic doses are smaller and less frequently repeated. The average dose of the antitetanic serum furnished by the Health Department of the City of New York is twenty centimeters. The injections are usually made under the skin of the back or thigh in cases not urgent. In hyperacute cases they may be introduced directly into a vein. Intracranial injections of from five to seven cubic centimeters into the frontal region of each hemisphere, after the skull has been perforated on both sides, have a still greater efficacy. The serum should be allowed to diffuse itself slowly beneath the dura. As this method is not devoid of danger, it should be reserved for hyperacute cases, and for those in which no benefit is derived from the subcutaneous and intravenous use of the serum. The results following the use of intraspinal injections have been disappointing in my hands.

Carbolic acid, injected beneath the skin in from ten to thirty drop doses of a 1 per cent solution, every three or four hours, has been used extensively in Italy (Baccelli). It is of less value than the serum treatment. There is no objection to combining the two.

The nutrition of the patient is to be maintained by nutrient enemas, and by means of a tube passed into the stomach through the nostril, when swallowing is impossible. Chloroform may be given to effect this. The hydrate of chloral may be given in milk introduced in this way. It may also be given in nutrient enemas. Physical and mental rest must be enjoined. The patient should be placed in a dark, quiet room, and every possible source of excitement and noise avoided.

HYDROPHOBIA

This is a disease of man and certain other mammals, and, like tetanus, belongs to the class of wound infectious diseases. It arises from the bite of a rabid animal, the saliva being the infection-bearing medium. The virus of the disease may be transmitted to all warm-blooded animals. The disease in man is caused most frequently by dogs, both because of opportunity, and because the saliva of infected dogs is more virulent than that of other animals. By some it is believed, however, that danger of the development of hydrophobia is always greatest when the bite is inflicted by a wolf.

Clinical Course.—The first onset of the disease does not occur until after a comparatively long period of incubation. In rare instances this may be as short as fourteen days; it has been prolonged to twenty-two months. The younger the patient, the shorter the incubative period, as a rule.

This stage of the disease is said to be lengthened by depressing influences. The healing of the wound is generally uninterrupted. During the initial stage of the disease a reddening with burning and itching, and sometimes actual pain at the site of the scar, is observed. This may radiate along the course of the nerves of the limb. Anesthesia and hyperesthesia are also present at times. During this stage there are some ill-defined symptoms, such as melancholia, irritability, and disturbed sleep, alternating with restlessness and short periods of joyous excitement.

With the onset of active symptoms the characteristic symptoms of the disease make their appearance. These refer to mental excitement conjoined with spasms of the muscles concerned in respiration and deglutition. There is at first a sense of choking, which is soon followed by spasms of the laryngeal muscles. A profuse salivary secretion is present, which becomes mingled with viscid, tenacious mucus from the fauces. Attempts to drink excite such painful spasms of the pharyngeal muscles that the patient soon abandons the attempt, and cannot be induced to repeat it. Spasm of the glottis also takes place as a result of the effort to swallow. General tremors may occur, and even convulsions. The temperature is always increased to from 101° to 103° F. The pulse is not markedly increased at first, but later on becomes rapid and feeble, and sometimes intermittent. The skin is hot and dry; just before the fatal issue a cold and clammy perspiration may be present. Priapism and satyriasis are observed.

A most disturbing symptom, present from the first moment the disease is suspected to exist, and lasting to the very close, despite the most positive assurances and consolation, is the fear of impending death. The mental faculties are not, as a rule, impaired, though occasionally the patient has hallucinations of sound and hearing.

Etiology.—It can no longer be doubted that hydrophobia is a disease of microbic origin, though its specific microorganism has not as yet been discovered. It seems now very certain that the virus cannot be reproduced except within the living organism. The smallest amount of this introduced within the body will produce the most serious consequences. The symptoms bear such a strong resemblance to those of tetanus that it is probable that the development of the disease is due to the action of the ptomains of the microbes on the nerve-centers.

The specific virus seems to be generated within the glandular appendages of the mucous membrane of the mouth of the rabid animal, and is transmitted by the saliva. Only a certain proportion of persons bitten by rabid animals contract the disease, about one-fourth escaping (Renault).

The route of entrance is usually a punctured wound made by the bite of a rabid animal, though the saliva deposited on an abraded surface may suffice for the inoculation. The microbe does not penetrate the uninjured skin or the mucous membrane.

Prognosis.—The disease in man is invariably a fatal one. No case of recovery from genuine hydrophobia is authentically recorded. In the majority of cases death occurs during the first four days. It is rare for the patient to live beyond the second day. The length of time from the infection of the bite until death takes place is from the twentieth to the sixtieth day. Death, as a rule, occurs unexpectedly from either apoplexy or asphyxia;

or rapid exhaustion may carry off the patient. A stage of paralysis may precede death, the patient lying relaxed from two to eighteen hours.

Pathology.—There are no gross pathologic changes in the disease. The scar, in some instances, may be red and somewhat swollen; this is not by any means constant, however. The cerebral ganglia, particularly of the pneumogastric and trifacial nerves, and the spinal and sympathetic ganglia undergo certain distinctive changes, inflammatory tissue taking the place of the destroyed nerve cells. Well-defined vascular lesions in the nerve-centers of the cord and medulla may be detected; these are less defined in the spinal cord, still less in other parts of the nervous system. An accumulation of leukocytes around the vessels in the substance of the medulla and cord is usually found. There is well-marked hyperemia and edema of the substance and membranes of the brain, spinal cord, and medulla oblongata.

Treatment.—When a person is bitten by an animal known or suspected to be rabid, inasmuch as the virus is slowly diffused in the system, no time should be lost in resorting to the most radical prophylactic measures at command. These may be efficient, even if applied after several days. Excision of the wound affords the best hope of preventing the disease. A tourniquet should be applied on the proximal side of the wound, and in the absence of professional help, an attempt made to remove the virus by suction. The tissues in the immediate vicinity are to be dissected out, and the wound sutured.

Cauterization of the wound may be most effectually performed with the actual cautery, the point of the Paquelin cautery, if this instrument is employed, being thrust deeply into the wound. The parts are afterward dressed antiseptically. Caustic potash, nitric acid, and nitrate of silver are less efficient.

Statistics show that a large proportion of persons who have been bitten by hydrophobic animals escape infection when these measures of prophylaxis are employed.

The **inoculation test** by which it may be demonstrated whether or not the animal is rabid is carried out by killing the latter at once, removing the medulla, and rubbing this up with sterilized salt solution. The emulsion thus obtained is injected into the subdural space of a rabbit. If the virus of hydrophobia is present, the inoculated animal will speedily develop the disease.

The person bitten should be sent at once to a branch laboratory of the Pasteur Institute, where immunization may be promptly carried out.

Pasteur's Prophylactic Inoculation.—The varying periods of incubation in different cases suggest that this, the latent stage of the disease, depends either on the slow growth of the microorganisms, or on the fact that they reach the point where they exert their noxious influence very slowly in some cases, and more rapidly in others. The differences in this respect may depend on the fact that the tissues in which the virus was originally implanted permit reproduction of the microbe but slowly in some instances, and more rapidly in others. On the other hand, it was discovered by Pasteur that if the virus is introduced directly into the brain of the animals, a fixed period of incubation precedes the development of the disease. Subsequent inoculations are marked by a still shorter period of incubation.

Pasteur made the additional important discovery that the virulence of the infected spinal cord in rabbits may be diminished progressively from the highest degree to the lowest or even rendered inert, according to the length

of time the cord is kept in a drying room, in a pure, dry atmosphere. This is accomplished in from seven to eight days. Fourteen days' drying will completely destroy all virulence. By using the spinal cords of rabbits treated in this manner in varying strengths, commencing with the weakest and gradually approaching the strongest, he found that when the latter were reached, the animals did not respond to the inoculation. In other words, they became immune. After demonstrating the accuracy of these observations on dogs, Pasteur (July 5, 1885) applied the method to persons bitten by rabid animals. The long period of incubation enabled him to apply the treatment to those who came from a distance, and during the first five years of its application nearly eight thousand persons who had been bitten by supposed rabid animals were thus treated. Of these, only 0.92 per cent died, a most extraordinary saving of human life, when compared with the fact that in former times 16 per cent died of hydrophobia, all those who were actually bitten by rabid animals, as well as those supposedly bitten, being taken into account. As those bitten by rabid wolves develop the disease much more certainly than those bitten by dogs, a crucial test of the method consisted in the prophylactic inoculation of this class of cases. Thirty-eight were submitted to the treatment, and of these only 7.89 per cent died. A collection of one hundred untreated cases of persons bitten by hydrophobic wolves showed a mortality of 82 per cent (Pasteur).

In view of the results obtained, the deadly character of the disease, and its probable development in those bitten by a hydrophobic animal, it is recommended that all persons who have been bitten by animals suspected to be rabid be subjected to Pasteur's prophylactic inoculation.

SECTION V

THE CHRONIC SURGICAL INFECTIONS

SYPHILIS

This disease has been known since the very earliest times, if we may judge from the fact that its symptoms are described in the ancient literatures of the earliest known races, such as those of China, Mexico, Peru, Greece, and Rome, and in sacred writings of the Hebrews. Renewed interest in the disease was awakened in the fifteenth century, coincidentally with the discovery of the continent of North America, and on this account it has been supposed by some writers that the disease was introduced from this continent. It is probably true that the impulse given to traffic between nations by that discovery led to extension of the disease. Communities theretofore immune became infected, and, as is usual where the soil on which specific infections are implanted is virgin, the epidemics of the disease were marked by exceptional severity. At the present day it exists practically all over the world, particularly among those nations with great commercial activities, and in the crowded centers of trade. Rural populations are happily quite free from it.

Syphilis is a specific infectious and chronic disease, limited to man, having its origin either from the contact of a sound individual with one infected with the disease (acquired syphilis) or from heredity. The disease, beyond question, is to be classed with the infectious granulomas, and is caused by the introduction of a specific microorganism into the human economy. The infectious agent is transmitted through the medium of fluids furnished by the pathologic tissues of infected individuals. A number of observers have claimed to have discovered a specific microorganism of syphilis. The latest of these, Max Joseph and Piorkowski, isolated a bacillus which, when cultivated on sterilized placentae, closely resembled that of diphtheria. When it was transferred to artificial media and cultivated for successive generations, the size and form as well as the numbers and vigor of the bacilli diminished considerably, these being restored by reinoculation on blood-serum.

The disease is conveyed by inoculation through the skin or mucous membrane, or the virus may exist in the embryo or be transferred through the placenta. The inoculation takes place most frequently from immediate, rarely through mediate, contact. In the vast majority of cases the disease is contracted during coitus and is therefore classed as a venereal disease. It may be contracted, however, by kissing a person infected with the disease, in examinations of syphilitics or in operations on them, or, rarely, by contamination from any article on which syphilitic virus has been spread. The last named is what is known as "mediate infection."

The Course of Acquired Syphilis.—In the acquired form of the disease the virus enters the organism at the point of infection and always begins as a hard chancre. This appears after a relatively definite and characteristic

interval following the exposure to the virus and the reception of it. A so-called **"primary incubation period,"** extending usually from two to four weeks, intervenes between the reception of the virus and the appearance of the chancre, or initial lesion, as it is sometimes called. This is followed by the **"secondary incubation"** period, occupying from two to eight weeks, after which there develops the primary regionary lymphadenitis, then the secondary general lymphadenitis. Coincidentally with the latter, in many cases, symptoms which usher in the acute infectious diseases are observed, such as nervous disturbances, debility, anemia, elevation of temperature, headache, and pains in the extremities; less frequently periostitis and prodromic papules.

At the end of the second incubation period further evidences of constitutional syphilis appear. There is frequently more or less febrile movement preceding the outbreak of the first exanthem, namely, the roseola. The heating of the surface may precipitate the occurrence of the rash, as, for instance, when a warm bath or excessive exertion immediately precedes the latter. The roseola makes its appearance in the majority of instances in from seven to nine weeks after the original infection. From this time on, the course of the disease is that of an irregularly relapsing chronic infectious disease. The relapses alternate with periods of more or less complete latency, as far as may be judged by the symptoms. It is not to be supposed, however, that the disease itself is not progressive, even during these periods of apparent quiescence. A gradual and continuous progression of the disease takes place from the moment the infection gains entrance, and no distinct line of demarcation can be made between the successive manifestations of the disease as they appear in any individual case. A general involvement of the lymphatic glandular system, the so-called "secondary lymphatic adenopathy," as distinguished from the primary lymphatic adenopathy, which occurs near the site of the chancre, marks the entrance of the toxic products of the latter into the general circulation, and, from this time on, the characteristic phenomena of the infection are observed as the evolution of the disease progresses. The red blood-cells commonly decrease and the leukocytes increase. The general lymphatic involvement manifests itself by a somewhat symmetric enlargement of the glands, thereby differing from the adenopathy near the site of the chancre, which is rather asymmetric. These phenomena, together with those already mentioned, stamp this as a steadily progressive infection; the halt between the appearance of the initial sore or chancre and the occurrence of the skin eruptions is more apparent than real.

All the organs are more or less disturbed in their function. The spleen, liver, and stomach notably take part in these disturbances. The nervous system may suffer, as shown by the neuralgic pains along nerve-trunks and by the peripheral pains as well. Febrile disturbances are not uncommon (**syphilitic fever**). There are pains in the bones and joints; synovial effusions may occur. In severe infections the lassitude and depression are profound, with mental lethargy, followed by attacks of syncope and headache.

All grades of severity of the disease may be observed, and the terms "benign" and "malignant" have been employed to designate these. These terms have but a relative significance, particularly the term known as benign, though all grades of malignancy also may be recognized.

Benign Syphilis.—This includes (1) cases with mild and transitory symp-

toms; (2) cases with relapsing or persistent superficial symptoms. Those cases with mild and transitory symptoms may present an apparent arrest of the disease after the appearance of a hard chancre and the presence of the characteristic local lymphatic glandular changes, the individual thereafter failing to react to the disease. As far as any outward sign of generalization of the latter may indicate, the patient is immune, and cannot thereafter be inoculated. Or, as more frequently happens, lymphatic glandular enlargement occurs in the occipital region or along the nucha, and later on along the sternomastoid muscle. The disease then progresses to the production of a macular skin eruption on the abdomen or over the chest, or both. With the subsidence of this exanthem the disease appears to terminate. A case may pursue the course above outlined with absolutely no treatment. The symptoms present, though typic, are of an astonishingly mild type. These cases differ from the foregoing in the degree of immunity exhibited.

In the second group of cases, namely, those with relapsing or persistent superficial symptoms, the manifestations, both of the initial lesion and of the general disease, are in every respect typic, yet at no time scarcely more than an annoyance. The special features of this type are the persistency of the relapses and the mildness of the symptoms, the latter of which relate particularly to the superficial skin eruptions. The majority of cases of syphilis belong to this group. There can be no doubt that, in the course of the natural history of the disease, in a large number of cases the destructive lesions never develop. This will account for the so-called "cures" by infinitesimal dosage, mind cures, as well as for the ignored cases. Nevertheless, the fact should not be overlooked that the mildest cases in the beginning may become the severest in the end. Therefore there should be no relaxation in vigilance in respect to even the mildest cases.

Malignant Syphilis.—This is fortunately a rare form of infection. The malignancy is probably due either to an extraordinary susceptibility of the individual to the disease, as occurs when the latter is introduced among a race or people for the first time, or to a lack of resistance to the infection and its rapid propagation in the tissues of the patient whereby the entire organism is overwhelmed by the virulence of the poison.

The malignancy of this class of cases may be exhibited early in the case or soon after the chancre stage, and continue only through the exanthem period, this including the time when lesions of the mucous membrane and general enlargement of the glands occur (the secondary stage of Ricord). Or, it may continue and manifest itself in connective-tissue hyperplasia, or gummatous deposits (**syphilomas**), which constitute the late stage of the disease (the tertiary stage of Ricord). In the meanwhile the patient shows signs of a deterioration of the general system (**syphilitic cachexia**), with high fever, loss of flesh, and pains in various parts of the body—in fact, all the evidences of a profound systemic poisoning. Disturbances of the nervous system, such as aphasia, epilepsy, coma, and paralysis, have been observed. Degeneration takes the place of resolution in the case of the lesions. Ulcers, eruptive and gummatous, rupia, and even gangrenous areas may occur at the site of the rather sparse lesions. Gummatous deposits undergo processes of disintegration, leading to deep and gangrenous excavations where these can communicate with the surface. When restoration of these deposits takes place the implicated organs

are greatly damaged. Exceptionally all these destructive manifestations may occur early in the disease (**malignant precocious syphilis**).

Finally, the fact cannot be too forcibly impressed that the different types of the disease, as expressed by the terms "benign" and "malignant," may be merged the one into the other. Chief among the causes for this interchange may be mentioned the influences of environment, constitutional conditions, and the effects of treatment.

It has been customary to divide acquired syphilis into stages, namely, the primary, the secondary and the tertiary (Ricord). This division, though artificial to a considerable extent, is convenient for purposes of clinical study and therapeutic considerations.

The **primary stage** covers the two incubation periods before mentioned, namely, that which intervenes between the reception of the virus and the appearance of the chancre (the primary incubation period), and the interval between the appearance of the chancre and the occurrence of the characteristic exanthem, the roseola (the secondary incubation period). The **secondary stage** of the disease commences after an average interval of four or five weeks and is ushered in by the exanthematous outbreak of roseola (the macular syphilide). The **tertiary period** commences after the lapse of two years on an average, and embraces what are known as the late manifestations of the disease, the **gummas.** The gummatous lesions may be absent, even in the cases untreated; their presence is not to be expected in those who have been subjected to continuous mercurial treatment for two years.

The Lesions of the Primary Stage.—After the primary period of incubation, this lasting from twelve to thirty days (exceptionally even sixty days), the seat of inoculation undergoes certain characteristic changes which culminate in what is known as the **initial lesion, primary sore,** or **chancre.** The chancre is usually single and painless and may be overlooked owing to its situation (within the urethra in the male, and between the labial folds in the female, or in the mouth or throat). The primary adenopathy consists of an indolent enlargement of the lymphatic glands in anatomic relation with the primary sore (**bubo**).

The Lesions of the Secondary Stage.—These follow the secondary period of incubation in the primary stage (see page 195). Sore throat, syphilitic roseola (**macular syphilide**), and painless enlargement of the lymph-glands are the earliest manifestations usually observed in the secondary stage. The anterior and posterior chains of glands in the cervical region, the epitrochlear glands and those in the axillae and groins are, as a rule, easily palpated. Later on, and usually coincidentally with the disappearance of the roseola, another type of skin eruption makes its appearance, namely, the **papular syphilide.** Exceptionally, however, the latter appears before the subsidence of the roseola. The papular syphilide is a small, rounded, and distinctly indurated nodule of a brownish-red color. It usually appears first in the localities first affected by the roseola, namely, on the abdomen, chest, and back, and at a later period on the arms and thighs; finally, on the palms of the hands and the soles of the feet. Or this order may be reversed. Coincidentally with the cutaneous eruption small superficial erosions appear on the mucous membrane of the mouth and pharynx (**mucous patches**). The favorite locations for these lesions of the mucous membrane are the sides of the tongue, the lining of the cheeks, the tonsils and

pharynx, and the lips and angle of the mouth. Mastication is painful and the flow of saliva annoying. About the time when the above symptoms decline, or about the third month, the symptom of the falling out of the hair appears. This may amount to only a general thinning of the hair, or complete absence of hair in patches may result (**syphilitic alopecia**). The hair in different localities of the body may be affected, with the exception of the eyelashes; the latter are involved only through ulcerative action. The hair-follicles may be involved in an erythematous, papular, or pustular eruption, and scales or scabs appear on the scalp in conjunction with the alopecia. This symptom of the falling out of the hair may last for a variable time. It disappears spontaneously in a short time, as do most of the symptoms of this period of the disease, even in cases that are not treated. Permanent baldness may result when the papillae are destroyed and the hair-follicles obliterated by the presence of ulcerative lesions; this may also follow, to a greater or lesser extent, a simple erythematous or papular eruption. After the disappearance of the first exanthems, the latter may reappear in different shapes and combinations (**recurrent syphilides**). A papular and a pustular eruption may appear either separately or in combination, or these may occur with either a scaly or a pustulo-crustaceous eruption, or both. Other lesions occurring in this period, and somewhat allied to mucous patches, are the so-called **condylomas** or **moist tubercles.** These are situated in moist localities and on certain mucous membranes (*e. g.*, in the larynx), about the anal aperture and on the genitals. In the latter situations they appear as broad, flat warts with a purulent discharge (**condylomata lata**) and with a tendency to vegetate, though vegetating condylomas or papillomas are not necessarily of syphilitic origin. Finally, within the first or early in the second year there may appear small circumscribed and painless swellings under the skin, perceptible only to the touch (**precocious gummas**). These are of rapid growth, become adherent to the skin, and appear as inflamed indurations; the red color soon changes to a dull or coppery hue. Softening takes place; ulceration, however, is not the rule in cases subjected to treatment. As resolution takes place the gumma slowly disappears, leaving a peculiar copper-colored patch on the skin. If ulceration occurs, the softening begins early, fluctuation is felt, and the skin at the site of the gumma breaks down in several places. The points where softening first occurs coalesce rapidly, and an ulcer with a greenish base and with undermined, sometimes everted edges, results. Exceptionally, the development of precocious gummas may be slow and insidious. In other cases these lesions are accompanied by severe neuralgic pains and exquisite tenderness of the tumors.

The Lesions of the Tertiary Stage.—This stage of the disease may never be reached, even in untreated cases; in those that have been subjected to proper mercurial treatment for two years the so-called tertiary symptoms are practically wanting. The evolution of the disease at this stage is usually slow and insidious, and always erratic in its manifestations. The latter consist essentially of connective-tissue hyperplasia, or of masses made up of collections of small spheroidal and epithelial cells, and occasional giant cells (**gummas**). These lesions are situated in the skin, deep in the subcutaneous connective tissue, in the mucous membranes and in other structures. The larger gummas consist of firm nodules with a cheesy or necrotic center and present a somewhat characteristic grayish-white appearance; they are inclosed in a rather ill-defined translucent capsule.

No organ or tissue of the body is exempt from the infiltrations or deposits of these late manifestations of the disease, and the symptoms to which these latter give rise are as varied as are the functions of the parts attacked. In the skin patches serpiginous ulcers, rupia, and pustulo-crustaceous syphilides are observed. Gummatous deposits, followed by ulcerations, occur in the subcutaneous connective tissue. These lesions, as a rule, leave pronounced, and sometimes characteristic, scars. Those occurring on mucous membrane, particularly that of the pharynx, increase rapidly and break down early, causing great loss of tissue. Necrosis of the hard palate and of the bones of the nose occurs, with interference with articulate speech in the case of the former, and facial deformity in the case of the latter. Syphilitic deposits may take place in the lungs, liver, kidneys, and heart—in fact, in all the internal organs. The central nervous system is attacked with relative frequency. The bones and joints, as well as the tendons, muscles, and bursae, do not escape. A cachexia which is out of all proportion in its intensity to the organic changes present develops (**syphilitic cachexia**).

In favorable cases, or those in which the late symptoms just described yield to treatment, there occurs a tendency to a natural decline of the disease. This, however, may not occur until irreparable damage to one or more of the vital organs has been done, and permanent impairment of the health has taken place. Death as a direct result of the syphilitic infection, however, is not common.

THE GENERAL TREATMENT OF SYPHILIS

The self-limiting nature of the disease is now fully established. Women are particularly fortunate in this respect; in men also the disease occasionally runs its course to recovery of health without any treatment whatever. This circumstance has led to much heated discussion as to the proper methods to be employed to protect the patient against the ravages of the disease. The principal contention in this regard is in respect to the administration of mercury. Without entering into the merits of this discussion, it may be said that the experience of the profession for centuries has been in favor of this drug. Since the disease is one whose symptoms disappear spontaneously in a large number of cases, it is no wonder that many vaunted cures have been urged. The use of mercury in one way or another, however, has been for centuries the chief reliance in the treatment of this affection, and is likely to remain so. With the sole exception of quinin in the treatment of malarial diseases, the influence of mercury on syphilis stands unique in the history of therapeutics. As the benefits to be derived from its use are fully realized, the only question today relates to methods of administration whereby the maximum amount of benefit may be derived with the minimum of harm.

The objects of the rational specific treatment of syphilis are (1) to suppress harmful symptoms already in existence; (2) to prevent the occurrence of the connective-tissue infiltrations and gummatous deposits of the later stage of the disease; (3) to prevent the spread of the disease by (*a*) inoculation and (*b*) transmission to offspring; (4) to prevent damage to important structures and organs, and unsightly scars. The means to be employed for the attainment of these objects is the judicious use of the preparations of mercury

and iodin. The term "specific" as applied to these remedies relates to their peculiar value in the control of the symptoms. But no one can say, in a given case, that the disease is cured, even after a prolonged exhibition of these remedies, for it will occasionally show fresh manifestations of its continued existence after prolonged treatment and absence of all symptoms for years.

The proper time to begin the systematic medication in syphilis is on the appearance of the general manifestations. The reasons for this are (1) that the diagnosis may be assured beyond a doubt; (2) that the patient himself, on whom depends almost entirely the success of the treatment, may have convincing proof of his condition and persist in the treatment. Exceptionally, the treatment may be begun earlier, but this is always at the risk of unnecessary treatment, or the loss of confidence, and hence interest, on the part of the patient.

The Hygienic Treatment of Syphilis.—The importance of hygienic surroundings for the patient cannot be overestimated. Every effort should be made to maintain the general health at its very best, in order to diminish as much as possible the unfavorable character of the symptoms. It is unquestionably true that broken-down individuals in the declining years of life may acquire syphilis which will give rise to only mild symptoms, and that in spite of neglect and dissipation, while, on the other hand, young men in the best of health up to the time of infection suffer from a virulent form of the disease notwithstanding every care; yet these facts do not militate against the necessity for husbanding in every particular the vital resources of the patient.

The precautions to be taken relate particularly to the ordinary rules of everyday life. Cleanliness of the body by daily bathing is important. No special dietary need be laid down for the syphilitic beyond what is required in usual health except that, during the existence of mouth or throat lesions, articles of food that may tend to irritate these should be avoided. Wine or beer in moderation may be allowed if taken only at meals; unless, however, the denial of these is a very great deprivation to the patient, it is safest, in order to avoid the possibility of alcoholic excesses, to enforce total abstinence. Acids may be allowed unless, under some special exigency, mercury is being pushed and salivation feared. When irritable conditions of the stomach and bowels supervene as the result of necessary medication, these may sometimes be avoided by a change in diet. This failing, corrective medication, such as the preparations of bismuth, bicarbonate of soda, and finally small doses of opium, may be tried before the antisyphilitic remedies are suspended. Cachectic states demand ferruginous and other tonics, change of air if these fail, and finally of occupation as well. Among the health resorts the Hot Springs of Arkansas have acquired a well-deserved reputation. A sojourn at any one health resort is not calculated to be of benefit.

Due attention must be paid to the hygiene of the mouth. The teeth should be regularly cared for by a dentist, all ragged or projecting rough surfaces corrected and tartar prevented from accumulating. Mucous patches and resulting ulcerative conditions demand that the greatest care be taken to avoid irritating articles of food and drink, since, under the most favorable conditions, these lesions are frequently difficult of management. Smoking

should be prohibited during the active existence of mouth lesions, and a syphilitic should not be permitted to chew tobacco under any circumstances.

The tendency to the occurrence of superficial lesions (excoriations, condylomas, and ulcerations), in localities where the skin is thin and less resistant, and at the mucocutaneous junctions, demands that special precautions be taken as to cleanliness of the genitals and of the anal region. Washing the latter with soap and water after each defecation is not unwise nor uncalled for. The accumulation of moisture in these parts should be corrected by the use of some antiseptic drying powder, in addition to frequent bathing.

The Specific Treatment of Syphilis.—This should never be commenced until indubitable evidences of the existence of the disease are manifest (*vide supra*). The specific medicaments employed in the treatment of the disease are practically limited to the preparations of mercury and iodin. The influence of the former is more especially exercised in the early stages of the disease, while the latter is particularly useful in the later manifestations, or those dependent on gummatous deposits. More or less influence is exercised, however, by both drugs in all stages of the disease, and one may be employed to supplement the action of the other (the mixed treatment).

There can be no question that the tonic effects of mercury administered to syphilitics rest on entirely competent clinical proof (Keyes). The drug should be given in sugar-coated granules of the protiodid (Garnier and Lamoureux's) in increasing *per diem* allowances until the point of toleration (tenderness of the gums, colicky pains, etc.) is reached, care being taken that the patient's diet is such as not to provoke any of the symptoms which it is expected that the mercury will produce, *e. g.*, indigestion, diarrhea, etc. The full limit being reached, the "tonic dose" consists of one-half the *per diem* dosage required to produce the undoubted and undesirable effects of the drug. Individual cases may be able to tolerate only a still smaller dose. Mercury may be employed either by internal administration, by external treatment, or by subcutaneous method. The protiodid is the preferable preparation for internal use. A preparation that is uniform in its effects, is properly protected against change by climate, and yet one that is promptly released from its protective environment to be acted on in the stomach, such as sugar-coated granules of a trustworthy manufacture, should be selected. These should be given after meals twice daily; they should be commenced with one granule at a dose and continued in an increasing dosage every fourth day by adding a granule at successive times of administration. That is to say, on the morning of the fourth day an extra granule is added; on the fourth succeeding day an extra granule is added to the midday dose, and again on the fourth succeeding day an extra granule is added, this time to the evening dose. This is continued until the point of toleration is reached (*vide supra*). The latter varies in different individuals.

When the limit of dosage of the individual is reached, the question of continuing this, or of dividing it by two (the tonic dose), must be decided by the patient's condition. If the case is urgent the use of the protiodid may be continued, its use being combined with some preparation of iron to combat the tendency to anemia due to both the presence of the disease and the effects of such large doses of the drug, until either the urgent symptoms subside or

the more pronounced effects of the drug are obtained. A tonic dose should then be substituted for the full dose, and, unless a return to the latter is demanded by an outbreak of symptoms of an unusual character, it should be continued uninterruptedly for at least two years. During this time it may be necessary to alternate the tonic with the full dose many times. In case of the occurrence of an intercurrent malady the administration of the mercury may be temporarily suspended. After six months, if everything goes well, one-third of the original full dose, instead of one-half, may be considered as the tonic dose.

When the dose has been satisfactorily adjusted to the requirements of the case, and two years have passed, the treatment should be alternated with periods of rest of a month's duration. The drug should thus be given every other month for six months. At the end of this time treatment should be suspended pending further manifestations. If, at the end of another six months, the patient shows no further signs of the disease, he is to be considered cured and may be allowed to marry.

In the administration of mercury by the inunction method mercurial ointment is employed. From 30 to 60 grains is the daily dose for an adult. Mercurial vasogen is also employed. The ointment should be applied to portions of the body free from hair and should be well rubbed in once daily, at night if possible. A new location for the inunction should be selected each day until all of the available parts of the body have been employed for the purpose. The patient may make the inunctions himself, or the professional rubber may be employed. Another method of inunction consists in wearing a piece of flannel cloth on which mercurial ointment has been smeared (Teale). This is bandaged in position, and its location changed from time to time as signs of irritation appear.

The hypodermic (intramuscular) use of mercury is occasionally resorted to, if a prompt effect is required, the use of mercury by the mouth impossible, or the inunction method undesirable. Indeed, this method may often be employed in obstinate forms of palmar and plantar syphilides in which the other methods prove unavailing. The best preparation is the salicylate of mercury, twenty-four grains of which are mixed with one ounce of benzoinol. Thirty minims of this mixture, equal to one and a half grains of mercury, are injected twice a week in the upper and outer part of the buttock (Keyes), an extra long needle being employed in order to reach the gluteal muscles. The mixture should be well shaken before use, and the needle should be of extra large caliber in order to prevent clogging by the insoluble particles of the salicylate.

The occurrence of **salivation** is rare in properly conducted cases. The nearest approach to this in cases in which the progress of the disease is carefully watched and the dose of mercury properly adapted to its needs is the so-called "touching" of the gums as the full dose of the drug is reached. Should it be necessary to continue the latter, there is danger of salivation, and precautions should be taken to prevent this. These consist in a proper care of the mouth, as to cleanliness, etc., and the avoidance of acids in the dietary. The further preventive treatment of salivation consists in the free employment of baths and of diuretics, which encourages the elimination of mercury from the system. Chlorate of potassium in 2 or 3 grain doses repeated hourly,

given in a demulcent, such as flaxseed or slippery elm bark tea, exercises a soothing influence on the mucous membrane of the mouth.

With the full development of salivation the breath becomes highly offensive, the tongue at first coated and then swollen, the gums puffed, spongy and bleeding, and deep red or bluish in color. A profuse flow of saliva occurs. Symptoms of gastric irritation supervene; diarrhea is present. The general adynamic condition is marked and the patient becomes mentally depressed. In the final stage ulceration of the inflamed mucous membrane and sometimes gangrenous conditions occur, the teeth loosen and may fall out, and necrosis of the adjacent bony parts takes place. Under these circumstances a mouthwash consisting of a 1.5 to 2 per cent solution of carbolic acid, in which chlorate of potassium is dissolved in the proportion of 15 grains to the ounce, should be constantly used. Mixtures of borax and honey are also useful.

For the so-called **tertiary symptoms** of syphilis, or the late manifestations of the disease due to gummatous lesions, the treatment is the combined use of mercury and iodid of potassium (mixed treatment), which should be alternated, as the effects of the mercury become evident, with the iodid alone. The latter should be given in doses of from 5 to 100 grams three times a day, according to the urgency of the symptoms and the toleration of the drug. It must be given in sufficiently large quantities of Vichy or hot milk to insure toleration by the stomach (from an ounce to half a pint, according to the dose of the iodid reached). In cases in which the iodid of potassium is not well borne, or, because of the large quantity of fluid necessary as the massive doses are reached, I have employed with satisfaction the preparation of iodin known as iodonucleoid. This is nonirritating to the digestive tract when given in powder or tablet form, and may be combined with mercuric chlorid, iron, strychnin, etc. The dose is the same as that of iodid of potassium.

Syphilitic Reinfection.—One of the points upon which is based the belief of the curability of syphilis is the undoubted fact that the disease has been acquired a second time, the patient passing through its different stages twice. Inasmuch as the existence of the disease renders the patient absolutely immune from reinfection, as shown by numberless experiments, if reinfection occurs in the case of a patient who beyond question has suffered from the disease, the natural conclusion is that he had been cured of the disease.

Hereditary Syphilis.—In this form of the disease the infection is derived from one or both parents, subjects of the disease in its active form. The chancre is absent, the disease usually exhibiting general manifestations from the commencement. When active infection unmodified by treatment exists in both parents, or in the mother alone, the child is almost certain to be diseased. On the other hand, when the mother is healthy and the father alone is a syphilitic, the child may or may not be born a victim of the disease. The possibility of the transmission of syphilis to the child *in utero,* particularly in the later stages of gestation, is doubted by many eminent syphilographers. If the chancre is acquired by the mother simultaneously with the occurrence of conception, she usually aborts. It is generally agreed that if the chancre is acquired by the mother after the seventh month of pregnancy the child is safe. To this rule, however, there are exceptions. As to the possibilities of infection, however, in the intermediate period, authorities are not agreed. It is more than probable that if the mother acquires a chancre at any time between

the time of conception and the seventh month of gestation the child will be syphilitic.

The question of the infection of the mother through the presence *in utero* of the product of conception derived from a syphilitic father (*choc en retour* of Ricord) is of interest in this connection. That this may occur is very probable, since it is more than likely that the ovum becomes diseased through the spermatozoa, and that therefore the prolonged presence of the product of such a conception in the uterus may poison the mother. The experiment of attempting to inoculate an apparently healthy woman delivered of a syphilitic child conceived of a syphilitic father resulted negatively (Caspary). This observation supports **Colles' law,** namely, that a nursing mother never acquires a chancre of the nipple from her syphilitic offspring. **Chancres of the nipple,** however, are acquired by previously healthy wet-nurses from suckling syphilitic infants.

The virulence of the infection in the child will depend on whether or not the mother has been subjected to treatment during the period of gestation and how much treatment she has received. All grades of virulence or of modifications of the infection by treatment are observed, from the still-born child or one born with the most unmistakable signs of congenital syphilis and doomed to early death, to the child born apparently healthy, but developing the evidences of the disease later in life. Finally, if a syphilitic mother has been under proper treatment for two or more years, or if four years have passed by with or without treatment, she may give birth to a healthy child. The presence of gummatous lesions in the parents is not inconsistent with the production of offspring free from the disease.

The **symptoms** of hereditary syphilis are practically the same as those of the acquired form of the disease, with the exception of the chancre. Some of these, however, are accentuated in a peculiar manner in well-marked cases. The syphilitic dyscrasia is manifested in the small and puny body, the wrinkled skin and the pinched face (the "old man countenance"). Deformities of a varied character may be present. The macular syphilide and mucous patches about the anus and mouth are frequently observed at birth. Gummatous lesions in the viscera are not uncommon. In cases in which the virus has been modified by treatment during gestation the signs of inherited syphilis are not so marked, and the first suspicion of the existence of the disease may be awakened by the occurrence of digestive or nutritive disturbances, with the appearance, later on, of rachitic conditions, diseases of the bones and joints, lymphatic glandular enlargements, corneal lesions (keratitis), and skin affections. Thinning of the walls of the skull (**syphilitic craniotabes**) and thickening of the ends of the bones at the epiphysial line (**syphilitic osteochondritis**) may be present. The so-called **Hutchinson teeth,** generally considered as pathognomonic of congenital syphilis, consist of a narrowing and notched condition of the two upper central incisors.

The **treatment** of congenital syphilis is by inunction. Mercurial ointment, made in half strength, should be used. A flannel belly-band, in which the ointment is well incorporated, should be worn twelve hours out of the twenty-four. The nutrition should be maintained at the very highest possible point, and as soon as the digestive apparatus will permit tonics, iron and cod-liver oil should be administered in addition.

TUBERCULOSIS

By this term is meant tissue changes associated with the presence of the tubercle bacillus. The latter is the sole cause of tuberculosis (K o c h), though it is not always possible to demonstrate its presence in a tuberculous focus, a fact readily explained by the biologic characteristics of the tubercle bacillus. (For description of the tubercle bacillus, see page 30.)

Of late the bacillary nature of the factor of tuberculosis has been called into question through the demonstration of its polymorphous nature (N o c a r d and R o u x, M e t c h n i k o f f, and others), so that it is now classed among the hyphomycetes (streptothrix, K r u s e). Under certain circumstances the localization and propagation of the tubercle bacillus in the living body resemble those of the actinomyces (B a b e s and L e v a d i t i). The numerous clinical similarities of tuberculosis and actinomycosis can be readily understood through this biologic similarity.

The toxins produced by the tubercle bacillus are not yet clearly understood. The disproportion between the number of bacilli and the magnitude of the tissue changes induces the belief that there are specific bodies produced by the bacilli which are capable of causing profound alterations. In addition to the effects of the toxins it is possible that chemic combinations are produced in the infected animal or human economy which are the result of tissue necrosis caused by the tubercle bacillus, and which vary in quantity and toxicity according to the constitutional or hereditary characteristics of the individual. The complex of symptoms known as **tuberculous cachexia** is, to a certain extent, the result of the action of these toxins.

Clinically it is difficult to locate the point of entrance of the infection in individual cases, though numerous anatomic and experimental studies have clearly demonstrated the mode of entrance and the paths taken by the infection.

The disease travels at first from the point of infection by means of the lymph-channels; later on, and especially in the case of infection of more distant organs, the blood-vessels must be regarded as conveying the disease (K l e b s). In this way the cervical glands form the first point of arrest for bacilli entering by way of the mucous membrane of the mouth, the mesenteric glands the first point in intestinal infection, etc. The bronchial glands are infected through the lymphatics before the lungs necessarily become diseased. In all probability most forms of surgical tuberculosis (bones, joints, epididymis, etc., as well as visceral tuberculosis) proceed from a hematogenous infection (K ö n i g), though in many instances the primary focus cannot be determined. In many cases the introduction of the bacilli into the blood occurs in connection with a focus in juxtaposition with blood-vessels of small caliber into which perforation may occur (W e i g e r t, O r t h, N a s s e), or the transition into the blood-current is accomplished by means of the lymphatics (B a u m g a r t e n). As a third source of hematogenous infection is to be considered a primary disease of the intima (**tuberculous endangeitis**) (O r t h, S i g g, S t r ö b e, B e n d a). According to H i l d e b r a n d, this may result either from the transportation of an infectious embolus to some point where complete stenosis of the vessel does not occur from its arrest, as, for instance, at some point of bifurcation, tuberculous infection of the wall of the blood-vessel following, or

from the entrance into the blood-current of only comparatively few bacilli which are deposited on the vessel wall, causing an infection at one or more places.

The bacilli first develop at the point of infection, and are carried from there through the lymphatics to the neighboring tissues; then to the lymph-glands, and through these eventually to other points of the body. Unlike the point from which the infection of acquired syphilis gains entrance into the organism, the site of infection in tuberculosis does not necessarily involve either a demonstrable tissue defect or a tuberculous lesion; even microscopically there may be no tuberculous change. Animals fed on tuberculous material developed tuberculosis of the mesenteric glands more readily than a tuberculosis of the intestines themselves.

Pathologic Anatomy.—The irritation of the tubercle bacillus causes first a karyokinesis of the fixed cells (J. Arnold), the connective-tissue cells and the living endothelium of the vessels, these changes occurring first in the cells inclosing bacilli (Baumgarten and others). The tubercle bacillus is mostly found lying in the interstitial connective tissue, singly or in pairs, or in small or even large colonies.

The further changes which occur in the infected area consist of swelling of the connective tissue and endothelial cells; according to Virchow, it is the latter which are characteristic in the formation of a tubercle. The fibrous interstitial tissue thus formed is gradually absorbed through pressure from the proliferating cells until only a small reticulum (the fibrillary basement membrane) is left. The blood-vessels within the infected area become obliterated from the proliferation of their own epithelium, and the site of the disease appears surrounded with a wall of epithelial cells showing centrally two, three, or many nuclei; this constitutes the transition stage to giant-cells. With the segmentation of the nucleus before cell division actually takes place, the development of the cells ceases (Virchow, Flemming).

The diminution of the vitality of the connective-tissue cells and the progressive development of the giant-cells go hand in hand, and the latter becomes the precursor of the changes known as tissue necrosis and cheesy degeneration. The genesis of the giant-cells at the present time is unknown; Orth has shown, however, that the number of these cells is in inverse ratio to the extent and intensity of the infection, so that the observer is enabled to estimate, with certain limitations, the present state of the infection.

According to the degree of cellular attraction exerted by the tubercle as a whole, and the bacilli in particular (positive chemotaxis), a more or less marked diapedesis of lymphoid cells from the surrounding blood-vessels occurs. This takes place coincidentally with the occurrence of fibrin in the tubercle (Orth), though to this rule there are exceptions. Destructive processes now supervene. The tissue metamorphosis is terminated by either a slow or a rapidly spreading cell death; the lymphoid cells shrink, the nuclei disappear from the epithelioid cells, and the tubercle tissue breaks up in a finely granular detritus consisting of albumin and fat globules. Finally, cheesy degeneration occurs, and proceeds from the center to the periphery. In this way cavities are formed. Precisely the same series of changes takes place, whether the lungs, bones, lymph-glands, kidneys, etc., are attacked, the process differing only in extent and virulence. In the neighborhood of free surfaces or cavities,

such, for instance, as the skin, cavities lined with mucous membrane, the joints and vessels, a destruction of the covering membrane occurs secondarily to the progressive necrosis of the adjacent focus, and a **tuberculous ulcer** results. The peculiar undermining of the edges of these tuberculous ulcers is characteristic, and depends on the power of the enveloping structure surrounding the tissues to resist the spread of the tuberculous process. Exuberant granulations may bar the latter and assume the size of a tumor (**tuberculous granuloma**), or healing may take place by cicatrization of the focus.

The great bulk of the gummatous mass discharged from a tuberculous focus is made up of the degenerated tissue-cells; only a comparatively small part consists of leukocytes. The characteristic features of tuberculous granulations are (1) their anemic and occasionally cyanotic appearance; (2) their edematous condition and vitreous luster; (3) their proneness to break down. When a tuberculous focus communicates with the external air by means of a canal, the latter is called a **tuberculous fistula.** Pending the definite cicatrization of the central focus these fistulas may repeatedly break open again after healing. In cases in which spontaneous cure takes place this occurs either by separation and elimination from the system (sequestration) of the tuberculous products (granular detritus, degenerated tissue-cells, leukocytes and bacilli), by resorption of smaller necrotic foci, or by encapsulation and cicatrization. Encapsulated foci sometimes pass into a further stage of retrogressive change, namely, that of calcification.

Small bacillary foci may remain dormant for long periods of time, sometimes for several years, without causing any subjective or clinically objective symptoms (**latent tuberculosis**). Either of their own accord or under the influence of some exciting cause, such, for instance, as the presence of other infectious diseases, disorders of nutrition, or traumatism, these become active, or by rupture and direct discharge into the circulation alarming symptoms from new bacillary foci are produced. The importance of these facts and their proper recognition relate particularly to the prognosis of the disease. Absolute cure of tuberculosis cannot take place until all bacilli have been eliminated from the body or are no longer viable.

The relation between traumatism and local tuberculosis frequently becomes a question of medicolegal importance. While it is undoubtedly true that, in the large majority of cases, this relation does not exist, still the possibility of its occurrence demands consideration. If a patient is suffering from miliary tuberculosis, with bacilli circulating in the blood, and injury is inflicted at some part of the body, as a result of this the bacilli are deposited at the site of the *locus minoris resistentiae* and give rise to a so-called "local" tuberculosis. In this instance there must be established the evidences of a miliary tuberculosis. Or an already existing tuberculous focus may be injured simultaneously with a bone or joint, as a result of which fragments of tuberculous material are carried directly or by means of the lymph-channels into the blood-vessels and finally become localized at the site of the bone or joint injury. Here it is unlikely that the part affected by the injury should alone be selected as a place of deposit for the tuberculous tissue which has become disintegrated and entered the circulation. Animal experiments have shown that traumatism does not favor the localization of tuberculosis. Finally, an old latent focus may exist at the point affected by the traumatism and again become active through the circulatory

and structural changes caused by the injury. This third possibility is the most likely of all. It is in this class of cases particularly that a positive connection has been traced between tuberculosis and traumatism. The cases in question, however, must be few and isolated.

Treatment of Surgical Tuberculosis.—This must be both general and local. The first named includes dietetic and drug treatment. The second is subdivided into (*a*) methods to increase the local resistance and to assist connective-tissue proliferation; (*b*) methods to eliminate or destroy the bacilli.

The general constitutional treatment is of the greatest importance in surgical tuberculosis, and in many cases may overshadow all other methods. Chief among the measures imperatively demanded are climate and altitude, life out of doors in suitable weather and an environment with plenty of sunlight (sun parlor) at other seasons of the year, a suitable mixed diet, cod-liver oil and sea baths. The chief benefit to be derived from these methods of treatment is in great measure due to increased respiratory movements, increased appetite, etc. In the absence of opportunities for bathing at the seashore, home baths with sea salt may be employed. These, however, are less satisfactory than bathing in the sea.

Kapesser's green soap treatment consists in rubbing the patient from the neck to the knees with green soap two or three times a week, preferably in the evening. From 1 to 2 ounces are employed. The soap is washed off again with warm water after thirty minutes. The method has been found of great value, although its rationale is not clearly understood.

The local treatment may be considered under three groups: (1) local conservative measures; (2) specific antibacillary treatment; (3) radical operative measures.

First among the local conservative measures to relieve pain and to facilitate cicatrization is to be mentioned immobilization of the parts by means of plaster-of-Paris. This should be employed wherever applicable, particularly in tuberculous affections of joints. In addition to the effects of simple immobilization, it is probable that the pressure of the bandage likewise brings about more or less pronounced venous stasis, on which the Bier treatment is based (*vide infra*).

It has long been known that in pulmonary congestion, such, for instance, as occurs from certain forms of cardiac valvular disease, tuberculosis rarely occurs, and when present tends to heal in the presence of such pulmonary congestion (Laennec, Rokitansky). These facts led to the introduction of the method of artificial hyperemia in the treatment of tuberculosis of the extremities and epididymis (A. Bier). The first effect of this treatment is the almost immediate relief from pain. The curative results are to be ascribed partly to a bactericidal action of the blood itself, and partly to the increased proliferation of the connective-tissue cells. The most brilliant successes with this method have been observed in cases of synovial tuberculosis with fungous proliferation. The hyperemia is secured by means of thin elastic bandages placed proximally to the site of the disease in such a manner as to obstruct the return circulation and yet not interfere with the arterial flow. The limb beyond the diseased part is bandaged with a roller bandage (Fig. 36). The length of time for which the hyperemia is maintained varies in different cases from two to three hours to a day at a time. The method must be modified for individual cases.

Among the conservative measures for the treatment of surgical tuberculosis injections into the tissues and joints also deserve special mention. The injections employed up to the present time have been supposed to exert an antibacillary action. The drug employed most extensively is iodoform, either a 10 per cent iodoform glycerin (B r u n s) or the 10 per cent olive oil mixture (T r e n d e l e n b u r g). In the case of the iodoform glycerin, the marked action of the glycerin on the circulation, causing first exudation and then resorption, is not too greatly overestimated. Even in the case of the iodoform itself, the *modus operandi* of which is supposed to depend on the liberation of iodin, it is now believed that the bactericidal action is not so important as its action on the tissues. It has been demonstrated that, under the influence of iodoform, fungous granulations disappear and cell proliferation is checked, healthy vascular granulation tissue taking the place of the fungous granulations. Tissue containing tubercle bacilli becomes separated, and lastly a marked formation of connective tissue occurs, terminating in cicatrization (B a u m g a r t e n, M a r c h a n d, P. B r u n s, N a u w e r k). The 5 per cent iodin-potassium iodid injection (D u r a n t e) is advocated by some.

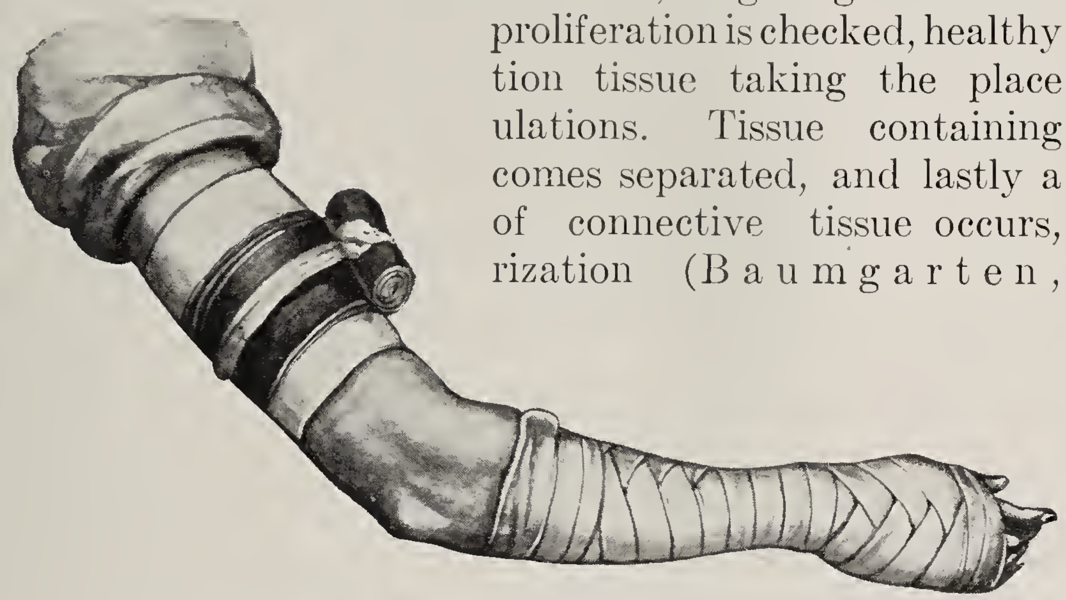


Fig. 36.—Bier's Method of Securing Temporary Passive Congestion in the Treatment of Tuberculosis of a Part.

P h o t o t h e r a p y (F i n s e n) and radiotherapy have been employed in tuberculous diseases. The use of these measures is purely empiric, and there is no well-defined theory as to their action.

Radical operative measures constitute the most trustworthy and speedy method of dealing with surgical tuberculosis, whenever the focus can be readily reached and removed without causing serious disturbance of function. The benefit to the general health which almost invariably follows the prompt and thorough removal of the tuberculous tissue is marked and lasting.

ACTINOMYCOSIS

This is a chronic infectious disease which occurs in domestic animals and man and is caused by the ray fungus (Actinomyces bovis, H a r z).

B o l l i n g e r, of Munich, in 1876, first demonstrated the fungoid nature and pathogenesis of the just visible, yellowish, and more or less opaque granules characteristic of the disease, which are present in the lesions, in the contents of bone cavities, and in the discharge from fistulous tracts. These granules, varying in size from 0.15 to 0.75 mm. in diameter, were regularly found in the central softened area of new growths of the jaw and tongue of cattle, popularly known as "lumpy jaw," which had previously been regarded either as one of the forms of sarcoma or as tuberculosis. In the earlier stages of their development the granules are of the consistency of soft jelly, and of a grayish-white color. Later on they become more opaque and yellow, and finally, particularly in cattle, the granule may be the seat of a deposit of cal-

cium salts (mulberrylike granules). The botanist Harz found that the granules were made up of several patches and suspected that they represented the conidia form of a mold. The latter grows on the foodstuff of cattle, the infection taking place through the fodder. It is usually forced into the tissues by means of a foreign body. The parasite is identical in man and beast (Weigert, Ponfick).

The fungus belongs in the same provisional group as the hyphomycetes, and is in intimate relation with the newer findings in the group of the tubercle bacillus (branching ray and club formation, Friederich, Levaditi), to which it bears a close resemblance in its effects on the tissues.

At first the granules consist of fine threads; later on these increase in thickness, become bulbous at their extremities (club-shaped or finger-shaped), and are arranged radially at the margins of the hyaline mass in which the threads occur. Masses of pus-cells are also present and make up a portion of the bulk of the granules.

The fungoid patches contain threadlike branching mycelia of from $\frac{1}{2}$ to 1 μ in diameter and from 1 to 6 μ in length, with a membrane which takes the anilin dyes but does not stain with methylene-blue. Simple double staining with hematoxylin and eosin, or by the method of Weigert or of Gram, is efficient. The mycelium is normally homogeneous; it is sometimes broken up into short or long rods and sometimes into bodies resembling cocci. In addition, cocci are present. These are sometimes arranged in rows, and at other times irregularly in the membrane. They are to be considered spores, since by growth from one or both ends true mycelia are formed. These spores, and perhaps the threadlike fragments as well, are the disseminators of the disease. Hyphae with regular segmentation are formed in conidia spores in cultures only under the most favorable conditions. In the body, however, the ends of the mycelia usually, though not always, undergo degeneration, the membrane becoming gelatinous, so that the club shapes and pear shapes manifested on staining result. By rupture of the membrane finger forms occur. The radiating mycelia with the peripheral clubs make up the typic feltlike patch of the fungus. After death of the fungus the club shapes may persist and may be found embedded in the cicatrix.

Pathologic Anatomy.—The living fungus brings about changes in the tissues not unlike those produced by the tubercle bacillus. It becomes surrounded by round and eosinophile granules, and beyond these by granulation tissue frequently containing giant cells. The tubercle-like mass thus developed is made up of round and epithelioid cells; this tubercle, however, does not undergo cheesy but hyaline or fatty degeneration. Fusion of two or more neighboring tubercles forms suppurating masses or abscess cavities; in this suppurative process no tissue is spared. Only in parenchymatous or very vascular organs an indurated area surrounds the connective-tissue processes. In connective tissue, however, the breaking down process goes on more rapidly and easily.

The large amount of inflammatory tissue which forms a thick, tough, brawny infiltration in connection with the lesions is a special characteristic of the presence of this fungus. This is due to the irritation kept up by the parasite as a foreign body, as well as to the cell-destroying products of its metabolism. The granulation tissue is always marked by great vascularity and

tendency to degeneration. The yellow color is sometimes present in the granulations. When infection takes place in subcutaneous areas, not infrequently small yellow multiple foci may be discerned through the intact epidermis. Clinically, however, only the actual identification of the fungus is of value in differentiating the lesions from those of tuberculosis and carcinoma. Mixed infections (streptococci and staphylococci) are not rare, these giving rise to marked fever. The central portion of the focus usually contains the fungus, where its presence may be detected by microscopic examination. It may be free or attached to the foreign body by means of which it gained access.

Symptoms.—Actinomycosis is essentially a chronic disease, lasting for months or years. Clinically, the cases may be divided into those occurring in the region of the head, the thoracic region, the abdominal region and the skin.

The Region of the Head.—In accordance with the usual mode of infection, namely, through the medium of foodstuffs, such as grain, etc., actinomycosis occurs most frequently in the neighborhood of the mouth. The infection spreads from the oral cavity by penetrating the mucous membrane of the gums, sometimes through the cavities of carious teeth, and extends to the jaws and soft parts of the neck. Involvement of the tongue is rare either primarily or secondarily. In cattle the penetration takes place between a tooth and its alveolus.

Swelling of one side of the face or an enlargement of the jaw ("lumpy jaw") usually occurs. This enlargement is most readily distinguished inside the mouth, where several fistulous tracts are also usually present, the discharge from which often contains the yellow, sulfurlike detritus characteristic of the disease. Tenderness on pressure is sometimes present, though pronounced pain is rare. Except in cases of mixed infection (*vide supra*), as a rule fever is absent. The tendency is always to progressive extension of the infection, the routes taken being in the direction of the soft parts of the neck, the pharynx, the vertebrae, the thoracic organs, and the gastrointestinal canal. In cases of infection of the upper jaw there frequently occurs by extension actinomycosis of the base of the skull and of the brain. Retropharyngeal and spinal cord involvement has been observed. The lacrimal canal and eyelids may be involved.

The Thoracic Region.—Involvement of the pulmonary organs may be either primary when due to inoculation by inhalation, or secondary when due to lesions about the lower jaw, more frequently the former. All the symptoms of a chronic pulmonary affection are present, namely, cough, mucopurulent expectoration, fever, and progressive emaciation. According to Hodenpyl, either the mucous membrane of the bronchial tubes may be involved, giving rise to symptoms of chronic bronchitis, or interstitial changes and abscess formation may occur with symptoms of bronchopneumonia. Finally, miliary invasion of the lungs may take place, the symptoms of which closely resemble those of miliary tuberculosis. Actinomycosis of the lungs is frequently mistaken for pulmonary tuberculosis. Extension within the thorax by way of the pharynx and esophagus has been noticed. Primary invasion of the mammary region has also been observed.

The Abdominal Region.—Here the gastrointestinal canal is primarily involved, the actinomyces gaining access to the stomach and intestines along with the food and resisting the destructive effects of the gastric juice and bile.

The mucous membrane is penetrated and the submucous connective tissue invaded, after which the mucosa may become involved to a superficial extent, or apparently escape entirely, the characteristic destructive process going on in the deeper structures. In the case of the intestine a small submucous tubercle appears which breaks down in the center and gives rise to a small ulcer. Exceptionally the latter may heal, leaving a pigmented and irregular cicatrix. The stomach and all portions of the small and large intestine, including the vermiform appendix, may be the seat of invasion. About one-half of the cases occur primarily in either the cecum or the appendix. The liver is frequently involved secondarily. Abscess of the liver, with rupture into the cavity of the chest, may occur. Extension posteriorly leads to involvement of the spinal column and invasion of the spinal canal; general metastasis may occur. The destructive process may extend anteriorly and externally and involve the abdominal wall.

The onset in abdominal actinomycosis is frequently quite sudden, the symptoms being those of catarrhal gastrointestinal disturbances, namely, vomiting and either diarrhea or constipation. Or obscure abdominal pains may be present for weeks or months. The frequency of origin in the cecal region may lead to the diagnosis of chronic recurring or chronic relapsing appendicitis. This is strengthened by the later appearance of a tumor in this region. Or, a tumor finally appears in the neighborhood of the umbilicus. In any case the tumor presents a somewhat irregular outline. Pain is usually present at this stage. With involvement of the anterior abdominal wall the infiltrated area softens, fistulous openings form, and the surrounding skin presents a peculiar livid hue, described by some authors as bluish-violet, merging into a bluish-gray (slate color) toward the margins of the infiltration.

Actinomycosis of the Skin.—There are trustworthy observations showing that inoculations of the skin with resulting local actinomycosis may take place. This may occur from chaff (Ammentorp, Reboul), from splinters of wood in the case of farm laborers (E. Müller), or from poultices (W. Müller). The lesions closely resemble those of tuberculosis of the skin.

The **pyemia** of actinomycotic origin presents an interesting picture. It constitutes the final stage of the chronic afebrile cases. In addition to the dissemination among the internal organs there occur multiple subcutaneous abscesses. The metastatic abscesses take place through the circulation. They may occur through rupture of a primary focus into a large vessel, such, for instance, as the jugular vein, of which there are five recorded instances (Sick), or, the disease having extended from the lungs or intestine to the liver, the infection is transported by the hepatic vessels. Dissemination through the lymph-vessels does not take place.

Diagnosis.—The diagnosis depends on the presence of the characteristic granules or colonies in the lesions or in the discharges from the sinuses leading from the same. These are not always discoverable with the naked eye; it is necessary to subject the suspected material to microscopic examination in order to distinguish the granules or colonies from necrotic tissue and collections of pus-cells, for which they may be mistaken. In pulmonary actinomycosis the fungus will be found in the sputum or in the discharges from fistulous tracts in the chest wall leading to the lesions. In examinations of the sputum care should be taken to differentiate the ray fungus from the common leptothrix of the mouth; the filaments of the latter are frequently found adherent to

epithelial cells; they are larger, straighter, and thicker than those of the former, and they do not branch, as do the filaments of the ray fungus.

The fact that dissemination by the lymph-vessels does not take place in actinomycosis should be borne in mind as an aid in differentiating the disease. The finding of the fungus, however, is the only positive diagnostic point.*

Prognosis.—The statistics compiled by Sick, of Kiel, are exceedingly interesting in this connection. In cases in which extension to the base of the skull and brain took place this complication was observed six times out of 61 cases occurring primarily in the upper jaw, and ten times out of 525 cases occurring primarily in the lower jaw. In a general way, cases occurring in the lower jaw offer a more favorable prognosis than those in the upper jaw. Of the 525 cases above mentioned, aside from the 10 necessarily fatal cases in which propagation to the brain took place, 4 proved fatal by secondary lung invasion, 3 by retropharyngeal abscess, and 1 by spinal cord involvement. In addition, there was 1 fatal abdominal case and 6 cases of general actinomycosis. Of 27 cases of actinomycosis of the tongue, all were cured by operation. The prognosis is equally favorable for circumscribed lip and cheek cases. Of 20 intrathoracic cases of pharyngoesophageal origin, 19 proved fatal. Out of 142 pulmonary cases, 5 are alleged to have been cured. In two of these cases the diagnosis was not assured, and in the remaining, periods of time varying from six months to two years only had elapsed between the commencement of the symptoms and the date of the report. In view of the now well-known latency of the pulmonary cases which finally prove fatal this is manifestly too short a time on which to base a statement of cure. In all probability the affection as it attacks the lungs is an irremediable one, death taking place by cachexia and metastasis to the liver. In abdominal cases the prognosis is relatively better, especially if the abdominal wall is involved and the process extends anteriorly and outwardly. In abdominal cases extending posteriorly death takes place from abscess of the liver. rupture into the lung or spinal canal, and general metastasis. Invasions of the colon proved uniformly fatal. Ninety-three cases of **actinomycotic appendicitis** have been reported, 19 of which recovered. The rectum was involved in 13 cases, 7 of which proved fatal. In a total of 214 abdominal cases, only 47 recovered; this does not include 30 cases which, according to the original report, were "recovering."

In rare cases there is a tendency to spontaneous cure. Sick asserts that there are two or three well-authenticated cases of this character.

Treatment.—The treatment is preferably surgical when possible. If the foci are situated where they can be safely removed, a cure may be confidently expected. Where complete removal cannot be effected, and this is the rule rather than the exception, free opening, partial excision, and the iodid of potassium treatment should be followed. The latter is used in a 10 per cent solution as an injection into the surrounding tissues, and internally in from 2 to 3 dram doses. The iodid of potassium does not act on the fungus, but on the tissues (Pruez, of Königsberg). In desperate cases arsenic has been of value. For local use tincture of iodin, nitrate of silver in stick or 1 per cent ointment, boric acid, and concentrated alcohol are all of value. As in tuberculosis, climate and out-of-door life exercise a favorable influence over the disease (Heusser).

* Reactions following tuberculin injections have been observed by Billroth, Eiselberg, and others.

SECTION VI

TUMORS

CLASSIFICATION

The etiology of tumors is unknown. Virchow has shown, however, that all the tissues in these new growths have a normal histologic prototype. Under these circumstances, therefore, the most natural and satisfactory method of classification for the study of tumors is based on their structural characteristics.

The term tumor may be applied to the following abnormal conditions, arranged in four groups:

1. **Connective-tissue growths,** or tumors of connective-tissue origin.
2. **Epithelial growths,** or tumors whose essential feature is the presence of epithelium.
3. **Dermoids,** or tumors containing skin or mucous membrane in abnormal situations.
4. **Cysts** differ in many respects from tumors, though clinically they possess so many features in common that it is convenient to consider them in this connection.

If the methods of classification of the zoologist are adopted, it may be said that each of these groups contains several genera and that each genus contains one or more species (Sutton).

From the standpoint of the practical surgeon the effects of tumors on the individual are of the greatest importance; hence it is usual to designate them as malignant and innocent.

Malignant Tumors.—Malignant growths possess the following characteristics: (1) they infiltrate the surrounding tissues; (2) they infect neighboring lymphatic glands; (3) they tend to recur after removal; (4) dissemination takes place in more or less remote organs; (5) in their natural course they inevitably destroy life. The two genera of tumors to which the term malignant is applicable are the sarcomas and the carcinomas.

Malignant tumors, wherever situated, tend to destroy life. The extent to which dissemination occurs is best illustrated in cases of melanosarcoma, in which secondary deposits occur in almost all the organs of the body, the tumors in the skin alone being sometimes numbered by thousands. The most decided examples of malignancy, however, are observed when tumors of this type occur primarily in nonvital organs and destroy life in a few months. Here death is due, not to interference with the function of the organ first attacked, but either to secondary deposits in remote and vital organs, or to combined septic and anemic conditions (cachexia). When a malignant tumor involves a vital organ, life is often destroyed before there has been time for dissemination to take place.

Environment.—The influences of environment are shown in the familiar

examples of cancer of the larynx, in which death takes place from suffocation or from septic pneumonia following ulceration, of death from starvation in cancer of the gastric orifices, and of death from renal disease in cancer of the prostate with urinary obstruction. The environment of a malignant tumor in its relation to treatment likewise exercises some influence on the life-destroying properties of the tumor, irrespective of the importance of the part attacked or the genus of the tumor. For instance, a periosteal sarcoma attacking the femur will, on recurrence, destroy life almost twelve times as quickly as a tumor with the same histologic characters situated on the tibia, both being submitted to amputation. From this circumstance Bland Sutton is led to suspect that variations in tissue actually constitute an altered environment. It is much more probable, however, that the differences in this instance are due to increased difficulties of relatively complete removal.

Malignant tumors rarely occur as multiple growths. Exceptions to this are found in sarcomas occurring in paired organs, such as the kidneys, adrenals, ovaries, and retinae of young children.

A malignant tumor may arise in an organ already occupied by an innocent tumor, such as occurs when a carcinoma attacks the endometrium of a uterus, the seat of a fibroid. Separate organs that are a part of the same system may be attacked concurrently by a malignant and an innocent tumor, as, for instance, in the case of a mammary carcinoma and on ovarian adenoma.

Innocent Tumors.—As differing from the malignant type of tumors, innocent tumors present the following: (1) they are inclosed in a capsule, as a rule, and when not so inclosed their manner of increase is by diffusion and not by infiltration or implication of the surrounding tissues, the latter undergoing no change; (2) they do not produce infection of the lymphatic glands; (3) there is no recurrence after complete removal; (4) dissemination never takes place; (5) danger to life arises only from mechanic causes or from accidentally produced septic conditions.

Environment.—While malignant tumors destroy life whatever their situation, the dangers arising from innocent tumors depend entirely on their environment and on irritating or disturbing conditions. For instance, a small nonmalignant growth situated in the spinal cord may cause death in a comparatively short time; an enlarged thyroid may cause sudden and fatal suffocation from pressure on the trachea (scabbard trachea); or a lipoma may become accidentally infected through a point of irritation arising from friction of the clothing.

Innocent tumors, unlike malignant growths, are often multiple. There is a tendency in this direction in all benign tumors except myelomas. Two genera of innocent tumors may present themselves simultaneously in the same individual, or an innocent tumor and a malignant tumor may appear under the same circumstances. An innocent tumor may precede the development of a malignant tumor in the same organ for many years. Finally, the rarest of all combinations is the presence of an innocent tumor surrounded by a malignant growth.

Structure of Tumors.—The usefulness of a classification of tumors based on the histologic features of tumors is emphasized by the fact that the histology and embryology of an organ point with comparative certainty to the various genera of tumors and cysts to which it is subject. Exceptions, how-

ever, are to be noticed in the liability of the salivary glands to pure chondromas and of the ovary to dermoids.

CONNECTIVE-TISSUE TUMORS

The various genera of the connective-tissue group of tumors are included in the following: (1) lipomas; (2) chondromas; (3) osteomas; (4) odontomas; (5) fibromas and myxomas; (6) myelomas; (7) sarcomas; (8) neuromas; (9) angiomas; (10) lymphangiomas; (11) myomas.

Lipomas.—A lipoma is a tumor composed of fat. The genus is limited to a single species. Its occurrence is more generalized than that of any other genus occurring in man, with the exception of sarcoma. It is found in the subcutaneous and subserous tissues; beneath the synovial and mucous membranes; in the muscular tissues and intermuscular spaces; as parosteal growths and in connection with the sheaths of nerves and the cerebral and spinal meninges.

Subcutaneous Lipomas.—The subcutaneous fat is the situation in which lipomas are most commonly found. In this situation they are irregularly lobulated, encapsulated, movable within the capsule, the latter being more or less adherent to the skin. They are usually single, though one or more may be found in different situations in the same individual. They are often symmetric and tend to become pedunculated. They vary greatly in size, from a marble to a man's head. Exceptionally they attain an enormous size. They are confined for the most part to the trunk and the parts immediately adjoining the same. They are occasionally found on the hands and feet, where they are liable to be congenital. They are more frequent in the former situation, where they simulate compound ganglions. Those of the palm probably originate in the lobules of fat lying between the lumbricales. They may occur in a vascular form on the face (nevolipomas), where they are probably nevi undergoing cure by fatty degeneration. Calcification may occur in old lipomas through deposits of earthy salts in the fibrous septa.

Subserous Lipomas.—These occur in the layer of fat on which the peritoneum rests, and are of special interest to the surgeon, from the fact that they are likely to occur in the subserous fat at the hernial apertures and be mistaken for a hernia. They may actually give rise to hernia by protruding into the inguinal or femoral canals and dragging with them a process of peritoneum. The latter may subsequently become the seat of hernial contents. Hernia of the bladder is particularly liable to arise in this manner. Subserous lipomas sometimes appear as fatty hernias of the linea alba, near the umbilicus. They may grow between the layers of the mesometrium and simulate ovarian tumors.

A lipoma having its origin in the fat behind the ensiform cartilage may occupy the lower portion of the anterior mediastinum, after having passed through the gap in the diaphragm in this locality. The subpleural fat is sometimes the seat of a lipoma (Rokitansky) which may make its way on each side of the chest wall, forming an intrathoracic and an extrathoracic portion (Gussenbauer).

Submucous Lipomas.—These are of exceptionally rare occurrence. They are found in children in the subconjunctival fat; on the lips; in the larynx on the aryteno-epiglottic fold (Holt, Sidney Jones); and beneath the gastric and intestinal mucous membrane.

Subsynovial Lipomas.—Those occurring in the knee-joint are of the

greatest surgical importance. They occur in this situation most commonly alongside the patella, at the site of the alar ligaments. The so-called lipoma arborescens is said to be associated with rheumatoid arthritis.

Intermuscular Lipomas.—The largest specimens of this variety are found in the intermuscular strata of the anterior abdominal wall. They are also found between the pectoral muscles, and between the muscles of the tongue. The so-called "sucking cushion," a collection of fat between the masseter and the buccinator muscle, has been considered by some a lipoma.

Intramuscular Lipomas.—These have been found in the deltoid, biceps of the arm, complexus, and rectus abdominis muscles. They have also been reported as occurring in a submucous uterine myoma (J. Smith, Lebert).

Periosteal Lipomas.—These are usually congenital, are of infrequent occurrence, and have been found in almost all portions of the skeleton. They spring from the periosteum and generally contain traces of striated muscular fiber.

Neurolipomas is a term applied to fatty growths springing from the sheaths of peripheral nerves. They are not usually diagnosed until after removal.

Meningeal Lipomas.—These are found both within the spinal dura and outside it, between the layers of the dura at the base, and on the sac of the spina bifida in the lumbosacral region.

The Clinical Features of Lipomas.—This genus of tumor is usually easily diagnosed, though under some circumstances the diagnosis may be exceedingly difficult. This is particularly true of the periosteal, perineurial, intramuscular, subserous, and meningeal varieties. In operating on tumors in the middle line of the back special care must be taken to recognize those connected with the spinal dura.

Treatment.—Although innocent in character, these tumors are not without harmful tendencies, and hence many of them will require ultimate removal. When single, they are likely to attain large proportions; but when a number are present, this tendency seems to be absent. When so situated as to become irritated by the clothing, or by some particular occupation of the patient, their removal should be strongly advised.

Chondromas.—These are tumors composed of hyaline cartilage. The genus contains three species, viz., (1) chondroma; (2) ecchondrosis; (3) loose cartilages in joints.

Chondromas, in their most typic condition, occur in relation to the epiphysial cartilages of the long bones in children and young adults. They are usually single, but may be multiple, particularly when they occur in the hands and feet. They are always encapsulated, painless, of slow growth, and firm to the touch, except when they have undergone mucoid degeneration. They may undergo calcification and they sometimes ossify. In rickety individuals they frequently occur from the presence of fetal cartilage (Virchow). Their occurrence in the parotid, submaxillary, salivary, and lacrimal glands constitutes one of the most striking anomalies in connection with tumors.

Small local outgrowths of cartilage are known as **ecchondroses.** They occur on the edges of articular cartilages, the laryngeal cartilages, and the triangular cartilage of the nose. They are specially common in the knee-joint after the age of forty, and have been thought to have some connection with rheumatoid arthritis. They occur as sessile or pedunculated nodules, which

may become detached and constitute a loose body in the joint cavity; or they may be still held by a slight fibrous attachment.

Laryngeal ecchondroses are rare. They may grow from any of the laryngeal cartilages, most frequently, however, from the posterior plate of the cricoid, though both surfaces may be involved and the cavity of the larynx encroached upon. They vary in size from a pea to a walnut. Those that project into the cavity of the larynx are covered with mucous membrane, which in exceptional instances becomes ulcerated. Intralaryngeal projections give rise to obstructed breathing and aphonia.

Ecchondroses springing from the triangular cartilage of the nose are occasionally observed, the treatment of which by removal is usually advised.

Loose Cartilages.—In addition to the detached ecchondroses already mentioned, pieces of hyaline cartilage are found in joints attached by narrow pedicles, or lying in depressions, from which they may become detached or dislodged. They vary in size and usually occur in flat discs. They may be single or multiple, and sometimes are found in the corresponding joints as well. They are believed to have their origin in enlarged synovial villi which undergo chondrification. Calcareous changes sometimes occur. The latter may take place without chondrification, or both changes may be absent, the loose body consisting simply of the enlarged and thickened villi.

The **treatment** of chondromas consists in incising the capsule and shelling out the cartilage. When a large number are present on the bones of the fingers, amputation may be necessary. Loose bodies constitute one of the conditions present in so-called "internal derangement of the knee-joint," for which arthrotomy and removal of the loose body become necessary. As a rule, small bodies give rise to more trouble than the larger ones, and present greater difficulties of removal on account of the uncertainty of locating them exactly when the joint is opened.

Osteomas.—These consist of ossifying chondromas, the growth of the osteoma taking place from the covering of hyaline cartilage of the tumor, precisely as the growth of a long bone takes place from epiphysial cartilage. Two species of this genus are recognized, namely, compact osteomas and cancellous osteomas.

Compact osteomas are identical in structure with the tissue forming the shaft of a long bone. Their distribution is rather general, but they seem to occur by preference in the frontal sinuses, in the roof of the orbit, in the bony walls of the external auditory meatus, where they have their origin in the numerous centers for cartilage formation in that neighborhood, in the mastoid process and the angle of the jaw. They are usually sessile, and are sometimes composed of dense tissue of ivorylike hardness. Those occurring at the margin of the external auditory meatus may obstruct the latter and cause impairment of hearing.

Cancellous Osteomas.—These resemble the cancellous structure of bone and usually possess a thick covering of hyaline cartilage. They occur generally in sessile growths, though they are occasionally pedunculated. They are of slow growth, but, though painless and benign in character, they may in time attain a size sufficient to cause pain or even imperil life by pressure on large trunks or important organs. They are often congenital and by some have been deemed hereditary. They are sometimes multiple and may develop

symmetrically as regards situation in the individual. They have been known to attain large proportions and to become the seat of sarcoma.

Exostoses.—Although these are not true bony tumors, but rather bony outgrowths, it will be convenient to treat of them in this connection. They occur as exaggerations of the normal bony projections at the site of the attachment of tendons, such, for instance, as the adductor tubercle. This form of growth is frequently found in the tendon of insertion of the adductor magnus, where exceptionally it may become pedunculated and is sometimes covered by a bursa. Exostoses are rather frequently found on the bones of the face, particularly on the nasal process of the superior maxilla. The so-called horned men of the West Coast of Africa are subjects of the latter deformity.

The **subungual exostosis** is a small bony outgrowth, averaging about the size of a cherry pit, springing from the ungual phalanx of the great toe. It crowds its way through the matrix and appears as a dull red projection between the nail and the skin. Ulceration of the overlying soft tissues is liable to occur. These growths are the result of inflammatory processes having their origin in shoe pressure.

Treatment.—Osseous tumors require removal whenever they appear in accessible situations and interfere with the function of a part or press upon nerves. It is also advisable to remove them when they occur in favorable situations for osteosarcomas or chondrosarcomas of the extremities, *e. g.*, the tibia, the femur, and the humerus.

Odontomas.—These tumors arise from tooth-germs. The species in this genus is determined according to the part of the tooth-germ from which it springs, as follows: (1) epithelial odontomas; (2) follicular odontomas; (3) radicular odontomas; (4) composite odontomas.

Epithelial odontomas spring from persistent portions of the epithelium of the enamel organ, and are usually found in the inferior maxilla. They occur as small multilocular cysts separated by thin fibrous septa, the cavities of which contain a brownish-colored mucoid fluid. Care should be taken to distinguish these growths from endotheliomas.

Odontomas arising from the tooth follicle comprise the following: (1) **Follicular odontomas** (dentigerous cysts), or those tumors which represent an expanded tooth follicle. The cavity of the cyst usually contains viscid fluid and the crown or the root of an undeveloped tooth. (2) **Fibrous odontomas,** which consist of a thickening of the connective-tissue capsule or tooth-sac, in which a developing tooth is embedded. The thickened capsule prevents the eruption of the tooth. They are often multiple and are usually attributed to rickets. (3) **Cementomas.** These usually result from an ossification of the thickened tooth-sac constituting a fibrous odontoma, the tooth becoming embedded in a mass of cementum. They occur very rarely in man. (4) **Compound follicular odontomas.** These result from a want of uniformity in the ossification of the capsule of a fibrous odontoma, whereby a composite character is given to the tumor. Small fragments of cementum, or dentin, and denticles or even perfect teeth (Tellender, of Stockholm) are found in these tumors. They are rare in man.

Radicular Odontomas.—These spring from the root after the completion of the crown of the tooth. The tumor usually consists of an outer layer of cementum and an inner layer of dentin, with a nucleus of calcified pulp.

Compound Odontomas.—These are abnormal growths of all the elements of a tooth-germ, namely, the enamel-organ, papilla, and follicle, and therefore consist of enamel, dentin, and cementum. The tumor usually springs from one or more tooth-germs. They occur in both the superior and the inferior maxilla, attaining the larger size in the former. Occurring in the antrum of Highmore, they are frequently mistaken for exostoses.

The **diagnosis** of odontomas is of importance from the fact that considerable deformity and even excessive mutilation may result from their removal under the belief that malignant disease was present. This is particularly true of the fibrous variety, which is likely to be mistaken for myeloid sarcoma. The other varieties have also been mistaken for necrosed bone, for unerupted teeth, and for exostoses.

Treatment.—Follicular odontomas may be successfully treated by the excision of a portion of the wall, the removal of the contained tooth if one is present, and the thorough curetting of the cavity. The latter is obliterated by granulations. Enucleation may sometimes be practised in this species and is usually necessary in the others.

Dental Cysts.—A fibrous sac containing crystals of cholesterin is sometimes found at the root of a dead permanent tooth. These cysts vary in size from an apple seed to an English walnut. They spring from the roots of the teeth of both the upper and the lower jaw, and, in the former situation, may invade the antrum and simulate an abscess of that cavity. They are usually small and met with only accidentally in the removal of dead teeth. They may, however, give rise to a suspicion of their presence by their size or by the occurrence of suppuration.

The **treatment** of dental cysts consists in the removal of the tooth roots and the curetting of the cyst wall. In the case of those which invade the antrum it will be necessary to remove a small portion of bone in order to afford easy access to the cyst cavity. The after-treatment consists in frequently irrigating the cavity with an antiseptic solution and packing it with sterile gauze until it is obliterated by the process of granulation.

Fibromas.—Tumors composed of fibrous tissue are very rare. Those formerly described as such, particularly the "uterine fibroid," are now known as myomas and fibromyomas. Tumors composed of closely applied, long, slender, fusiform cells are observed in the ovary, the uterus, the gums, the larynx, on the sheaths of nerves, and in the walls of the heart.

Epulis is a term loosely applied to various tumors occurring on the gums, some of which spring from the tooth follicle (see Odontomas), while others are not tumors in the true sense, but are the result of inflammatory action. The growth sometimes called "malignant epulis" is a spindle-celled sarcoma. Small pedunculated tumors occurring on the mucous membrane of the larynx, and having a fibrous nucleus, are rather frequently removed by laryngologists by means of intralaryngeal operations.

Neurofibromas are encapsulated tumors springing from the sheaths of nerves. These growths vary in size from a small pea to a hen's egg. They occur on almost any portion of the cranial or spinal nerves as smooth, fusiform, and mobile swellings. They are liable to undergo myxomatous changes, with the formation of cavities in the interior. This has led to a confusion in the use of terms in designating these growths, such as myxoma, myxofibroma, myxosarcoma, etc. They are easily enucleated.

Myxomas.—These are tumors composed of soft jellylike material known as myxomatous tissue. It is identical with that which surrounds the vessels of the umbilic cord. The best example of this genus is the common nasal polypus. Aural polypi likewise consist of myxomatous tissue. Sutton describes a myxomatous tumor springing from the lumbar fascia which recurred after removal. He regarded it as a sarcoma which had undergone myxomatous degeneration.

The few examples of tumor of the heart which have been observed have been recorded as either fibromas, myxomas, or fibromyxomas.

Myelomas.—The tissue of these tumors is identical with that of the red marrow of young bones. The genus contains a single species, which is found only in connection with the cancellous tissue of bone. They are very vascular, and present on section a deep red color. They are characterized by the presence of numerous large multinuclear or giant cells, in a bed of round and spindle cells. They are found wherever red marrow exists, except in the vertebrae. They are rarely found in the patella or in the acromial end of the clavicle. They occur by preference in the upper end of the tibia, the lower end of the radius, the body of the lower jaw and the alveolar border of the upper jaw, and the sternal end of the clavicle. They are rarely seen in patients above twenty-five, and are of slow growth. A clinical feature of these tumors is the parchment-like crepitation present on palpation as the bony capsule becomes thinned by growth of the tumor. With perforation of the capsule pulsation may be present.

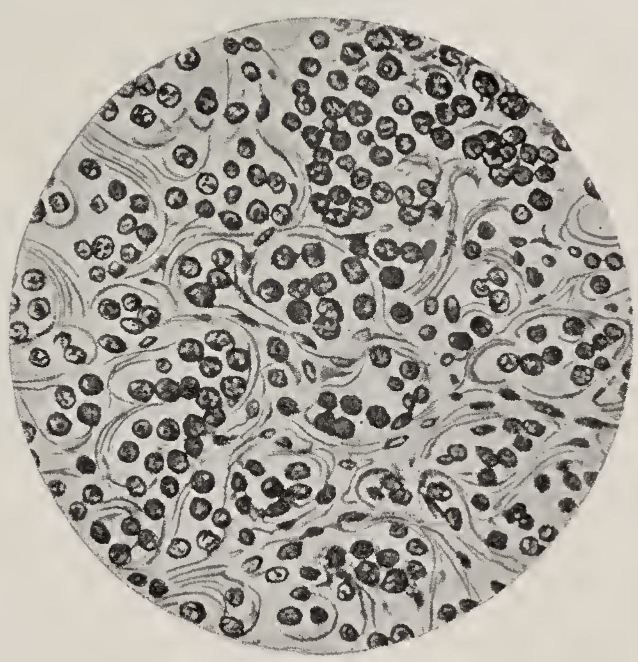


Fig. 37.—Round-celled Sarcoma.

While the vascularity of these tumors, as well as their occurrence in the long bones of young subjects, always excites a suspicion of malignancy, the absence of both infection of lymphatic glands and dissemination, as well as their non-recurrence if thoroughly extirpated before perforation of the capsule, stamps them as benign.

Sarcomas.—Sarcomas may be defined as tumors of connective-tissue origin, the special clinical features of which are embraced in the term "malignancy." Structurally, almost any kind of connective tissue, such as fat, bone, cartilage, and sometimes striated muscle tissue, may enter into their formation. The special histologic feature of sarcoma is the fact that the greater part of the tumor consists of immature connective tissue with a preponderance of cells over the intercellular tissue.

In the absence of all knowledge at the present time as to the cause of these aberrant growths of connective tissue, the most convenient scheme for determining the species is based on the prevailing type of cell present, or on the presence of pigment, as in melanosarcomas. The species having its origin in pigmented moles is called alveolar sarcoma. Each species may be subdivided into one or more varieties, with such qualifying names as lymphosarcomas, myosarcomas, chondrosarcomas, etc.

Round-celled Sarcomas.—This species is the most generalized tumor found in man. It may attack any portion of the body and occur in any tissue. It is found at all periods of life, even in the fetus *in utero*. It is very simple in construction, consisting almost exclusively of round cells, each of which contains a large, round, vesicular nucleus and a small proportion of protoplasm. The intercellular substance is very scanty, but is plentifully supplied with blood-vessels, which often appear as mere channels between the cells (Fig. 37). In the variety known as large round-celled sarcoma the cells are of unequal size, some of them being multinuclear and resembling myeloid cells.

Lymphosarcomas.—This rare and excessively malignant species derives its name from the resemblance of its tissue to that of the lymph-glands. It occurs particularly in the mediastinum, in the connective tissue beneath the pleura and peritoneum, in the tonsils and at the base of the tongue, and in the testes. The cells are identical with those of the round-celled species but are contained in delicate meshes (Fig. 38).

Spindle-celled Sarcomas.—This species derives its name from the fusiform character of its cells. Hyaline cartilage is frequently found in this species, from which circumstance it is known as chondrosarcoma. In other examples the sarcomatous tissue apparently consists of slender cells with almost an entire absence of protoplasm. In others, again, the cells are large, distinctly fusiform, and rich in protoplasm. They resemble the cells of young unstriped muscle-fiber; occasionally transverse striae are present, as in young striated muscle-fiber. This variety is known as **myosarcoma** or **rhabdomyosarcoma.**

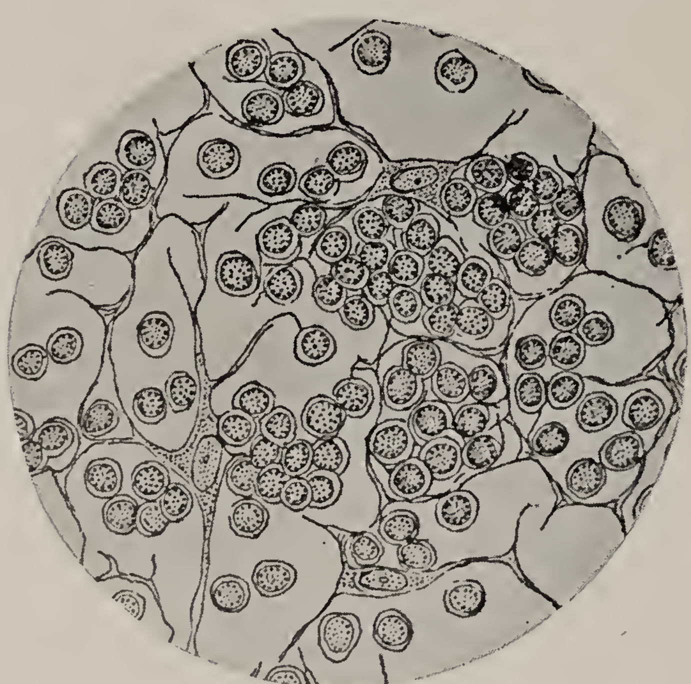


Fig. 38.—Lymphosarcoma.

In chondrosarcomas the presence of immature hyaline cartilage may be so pronounced as to confuse the diagnosis. This is particularly true when the cartilage is calcified or ossified; under these circumstances the tumor may be erroneously described as a simple chondroma. On removal, however, it recurs, and the recurrent tumor may show no evidence of cartilage but may conform to the structure of a pure spindle-celled or a round-celled sarcoma.

Myosarcomas.—Strange as it may seem, these rarely make their appearance in connection with voluntary muscles, but occur by preference in the kidney, cervix uteri, testis, and parotid glands, situations in which, under normal conditions, no muscle-cells of the striped variety are found. They have also been found at the angle of the jaw, in connection with the periosteum of the orbit, on the scapula and the tuberosity of the ischium.

Spindle-celled sarcomas occurring in the subperiosteal connective tissue of the abdomen and pelvis present some peculiar features, these consisting of an almost uniformly globular shape, large size, slow growth, and lesser malignancy as compared with the other sarcomas. These retroperitoneal sarcomas sometimes attain a large size; in a case operated on by the author the tumor

weighed upward of 30 pounds. They have been most frequently observed in the perirenal tissues and between the layers of the broad ligament.

The cells of spindle-celled sarcomas (Fig. 39) vary greatly in size and are prone to collect in bundles which form in different directions, so that when sections are made of the tumor mass the spindle shape of the cells is not uniformly preserved in the microscopic appearances, a circumstance which may easily lead to error in the histologic differentiation. When the so-called giant-cells are present, these are multinuclear (Fig. 40).

Melanosarcomas.—This term is applied to sarcomas in which pigment occurs. The greater majority of tumors containing pigment are sarcomatous in character. The amount of pigment present varies greatly. The pigment granules are found not only in and among the characteristic cells of the tumor and in those of the fibrous matrix, but also in the walls of the vessel.

This species of sarcoma, as it occurs usually in the skin, has its origin in connection with pigmented moles. It is next most frequently found in connection with the matrix of the nail, or in the neighborhood of it, or even in the nail itself. It also has its origin in the pigmented skin about the genitals and anus.

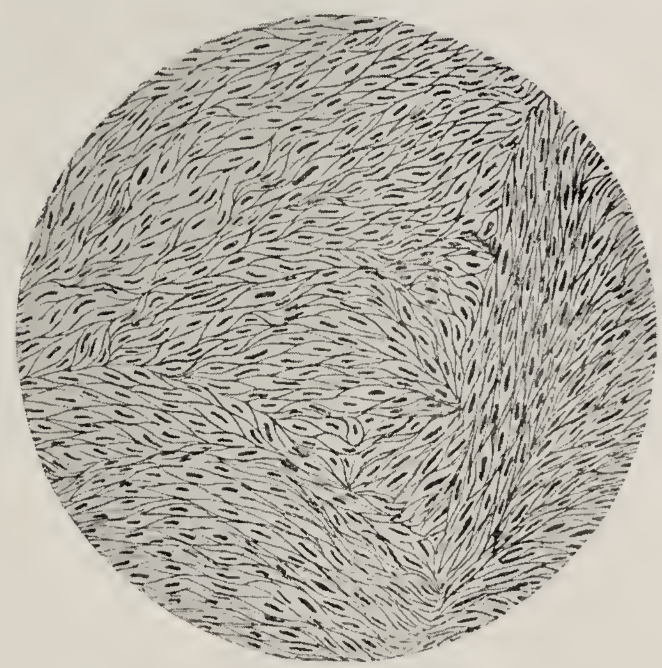


Fig. 39.—Spindle-celled Sarcoma.

While pigmented moles may remain quiescent for years, it occasionally happens that, as life advances, ulceration accompanied by bleeding takes place. Neighboring lymph-glands become the seat of secondary pigmented sarcomatous deposits, and the skin over these, becoming infected, breaks down, so that the fungous mass beneath is exposed. The latter gives rise to frequent hemorrhage, which is fatal when it occurs in the neighborhood of large vessels. Dissemination, which does not always take place, results in secondary deposits in the liver, lungs, kidneys, or brain. Lymphatic glandular infection, dissemination, and fatal secondary deposits in distant organs may occur from simple increase in size of the mole, without ulceration. Finally, in rare instances large quantities of pigment may be produced, apparently by the tumor, and fed into the circulation, to be eliminated by the kidneys as melanin, no secondary deposits of sarcoma taking place.

Nodules of melanosarcoma arising in connection with the nails usually ulcerate quickly, and rapid dissemination and secondary deposits are the rule. The pigment in the primary nodules is sometimes very scanty; the secondary deposits, however, may contain a large amount.

Melanotic tumors may be either sarcomatous or carcinomatous in character; in either case the characteristic feature consists of the more or less pronounced pigmentation of the growth. Inasmuch as the pigment particles have their origin in the normal sources of pigment, melanomas are found most frequently in the uveal tract of the globe of the eye and least frequently on mucous membrane. Their occurrence in the skin depends on the presence

of pigment in the rete mucosum, to which situation the pigment granules are almost entirely confined in the white race. The comparatively greater frequency with which these growths occur in the neighborhood of the anus and external genitals, particularly in the labia majora, is accounted for by the greater amount of pigment in these situations. The pathologic connection between the presence of pigment matter and the occurrence of melanomas has not as yet been satisfactorily explained.

The General Character of Sarcomas.—Sarcomas differ from all other connective-tissue tumors in the absence, as a rule, of a proper capsule, and the consequent ease with which infiltration of the immediately adjacent tissues and remote dissemination occur.

The vessels supplying sarcomas may be very large and numerous, though the circulation itself is mainly capillary. When the growth occurs in localities where the blood-supply is abundant and the arterial anastomosis free, as, for instance, in the neighborhood of the knee-joint, the blood-supply to the tumor from the vessels of the part is correspondingly increased and the hemorrhage is alarming in case of injury, ulceration, or when attempts are made to dissect out the tumor.

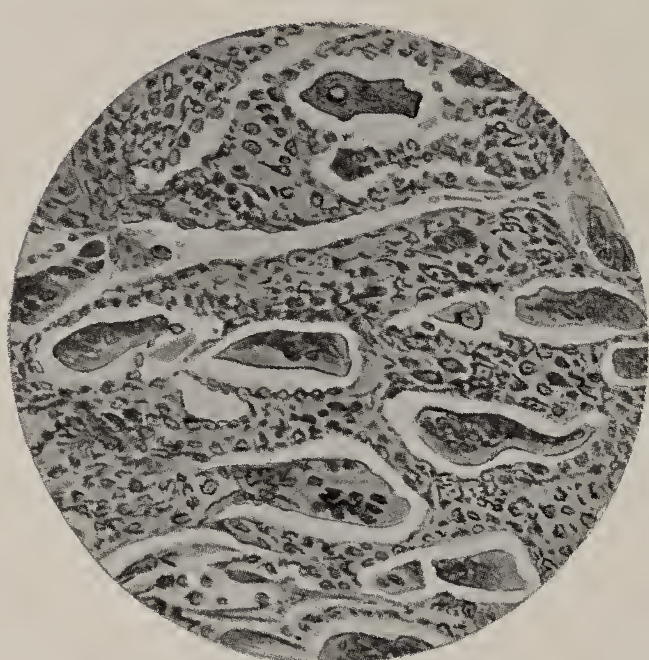


Fig. 40.—Giant-celled Sarcoma.

In the round-celled species, as well as in all soft and rapidly growing varieties, the circulation is specially free, as shown by the pulsation which is frequently present. Owing to the extreme tenuity of the vessel walls hemorrhage frequently occurs within the mass, after slight injuries. Under these circumstances large extravasations of blood may take place in situations in which the previous presence of a large growth may be easily overlooked, as, for instance, in the gluteal region, and the collection may be incised as an abscess.

The ever present and inevitable tendency of sarcomas to destroy life, as expressed in the term "malignancy," is displayed through (1) their ubiquitous distribution; (2) their infiltrating properties; (3) their tendency to penetrate between surrounding structures; (4) their dissemination.

Distribution.—While sarcomas may occur in any portion of the body, owing to the widespread distribution of connective tissue, they are observed springing with greater frequency from subcutaneous tissue and fascia, peritoneum, the testis and ovary. They are very infrequently found in connection with the spleen, bowel, or uterus, and occur as primary growths with great rarity in the organs which are usually first affected by secondary deposits, namely, the lungs and liver.

Sarcomas of mucous membranes are rare as compared with carcinomas of these structures. They were formerly supposed to occur in the endometrium of the uterus after full-term delivery or abortion (see Choriomas). Sarcoma of the **vagina** occurs in young children and in the middle-aged. Rare and exceptional instances of sarcomas springing from the mucous membrane of the alimentary canal have been observed.

The **infiltrating properties** of sarcomas are observed in a marked manner in localities where rapidly growing lymphosarcomas occur adjacent to extensive planes of connective tissue, as, for instance, in the superior mediastinum, where the growth envelops trachea and bronchi and extends to the roots of the lungs, follows the aorta and other large vessels to invest the pericardium, and even in some instances invades the heart. Projections of the tumor also pass in an upward direction along the sheaths of the large vessels to the head and appear in the posterior triangles of the neck. In this extensive infiltration the veins are first compressed, owing to the thinness of their walls, and interference with the venous circulation ensues. In some instances the walls of the veins are infiltrated with the sarcomatous tissue. The larger arterial trunks, though completely surrounded by the growth, are not, as a rule, appreciably compressed, nor do they become infiltrated. The trachea and bronchi suffer from compression, their nutrition is interfered with, and erosion follows. The nutrition of the lung tissue suffers from interference with the blood-supply and pneumonia and gangrene result. Difficulty of swallowing is not an invariable or marked feature in these cases, however, and neighboring lymph-glands may be completely invested by the growth without showing signs of infection.

The tendency of sarcoma to penetrate between surrounding structures differs from its infiltrating properties as follows: while in the former the extension takes place by growth from the periphery and the invasion is an actual vital process, in the feature under consideration the tumor follows the lines of least resistance in its penetrating or burrowing tendency, the process being a purely mechanic one. In this manner the cavity of the cranium may be invaded by a sarcoma originally springing from the upper jaw, which, after filling the sphenomaxillary fossa, forces its way alongside the second division of the fifth nerve through the foramen rotundum.

Joint cavities are exceptionally invaded by either of the processes of extension described. The synovial membrane seems to serve as a barrier in the case of the penetrating tendency of the growth, and the absence of venous channels in the articular cartilages removes the most favorable condition for infiltration. When joint cavities are invaded, it is through infection and implication of the synovial structures.

Dissemination or **metastasis** is that property possessed by sarcomas of reproducing themselves in distant organs. This process takes place principally through the veins, the sarcomas being devoid of lymphatics. It consists in the growth of minute portions of the tumor into the vessels, which become detached and are carried by the blood-current to remote organs. Here they are arrested by the capillaries, become engrafted, and grow as secondary tumors. Any organ of the body may become affected by sarcoma in this manner, and that, too, from a primary growth, whatever its location. If the primary tumor is situated in the area of the portal circulation, however, the liver will be the organ most likely to be secondarily affected; otherwise the lung is the organ in which secondary sarcomas are most commonly found.

Finally, the **secondary** or **degenerative changes** to which sarcomas are subject are to be mentioned. These consist of (1) the formation of spurious cysts from hemorrhage within the growth, as already alluded to; (2) liquefaction of the tissues of the tumor and myxomatous changes, the latter being rather common; (3) calcification in sarcomas of slow growth, particularly in those

connected with bone; (4) necrosis of the tumor. This is more frequently observed in the interior of very large tumors and results in the formation of a spurious cyst containing fluid and detached and necrotic portions of the growth.

Angiosarcoma, a rare and remarkable growth depending on a cellular overgrowth in the sheath of the smaller vessels, and on microscopic examination resembling superficially the lobules of the liver, has been described by Ziegler.

Treatment of Sarcomas.—The successful treatment of sarcomas demands early and extensive extirpation. Only considerations of safety should limit the extent of the latter. No operation should be undertaken unless it can be made to include every vestige of suspected tissue. When a limb is affected, amputation above the next joint should be the invariable rule. Even this may not be sufficient, as in the case of the upper third of the thigh. In the case of the arm, sarcomas of the humeral region, whether of the bone or soft parts, demand amputation of the entire upper extremity (W. W. Keen, R. S. Fowler). (See Interscapulothoracic Amputation (vol. ii). Sarcomas of the subcutaneous connective tissue or fascial structures, when situated on a limb, are best submitted to amputation. When situated elsewhere, they should be removed as frequently as they recur. Inoperable cases may be submitted to injections of the toxins of Streptococcus erysipelatis and Bacillus prodigiosus (Coley). Treatment by this method offers a slight hope, of which the patient should be given the benefit. Recurrences in regions inaccessible to further operation, particularly if the tumor is of the giant-celled variety, should also be treated by the toxins.

Neuromas.—A neuroma is a tumor springing from the sheath of a nerve, the structure of the neuroma resembling the structure of the sheath. They are usually observed as neurofibromas and include the so-called **subcutaneous painful tubercle.** This is a small, shotlike, and excessively painful and sensitive body felt beneath the skin. It occurs most frequently in men. Excision is always followed by cure.

The term **neurofibromatosis** is now applied to the following: (1) multiple neuromas; (2) molluscum fibrosum; (3) plexiform neuromas; (4) gliomas of the brain and spinal cord.

Multiple neuromas are of but slight surgical importance, except in those cases in which the growths are sufficiently few in number to admit of excision. The same may be said of **molluscum fibrosum,** which sometimes appears in a mild form as a single pedunculated growth, particularly in the labium majus. Exceptionally it may spring from the tissues in and about the nipple. When these occur in large numbers as sessile growths, they are not amenable to operative interference.

A form of fibromatosis confined to a particular nerve or plexus is called **plexiform neuroma.** This may affect any portion of either the cranial or the spinal nerves. There is a general enlargement and elongation of the nerves distributed to a part. The skin becomes raised and thinned over the area and is often a bluish color. The mass presents a rather uniform appearance (Fig. 41, 4) with a baglike feel. Mobile and nonsensitive bodies feeling like worms when manipulated and varying in size are present in the interior. The connective tissue of the nerve sheath is greatly increased and converted into a gelatinous material, like that of the umbilic cord. The presence or absence of changes in the axis-cylinder is as yet undetermined.

Gliomas of the brain and spinal cord are of but slight surgical interest, owing to the fact that their relation to the important structures in which they occur usually renders successful operative interference out of the question.

Angiomas.—The characteristic feature of this genus of the connective-tissue type of tumors is the abnormal formation of blood-vessels. Three species are included, as follows: (1) simple nevus; (2) cavernous nevus; (3) plexiform angioma.

Simple Nevus.—This may occur as a simple discoloration of the skin, in varying extent, and may affect any part of the body. These discolorations are commonly known as "port wine stains." The form known as **telangiectasis** consists of an abnormal collection of arterioles in the skin and subcutaneous connective tissue. It may be present at birth as a small red spot which may be easily overlooked. During the first few weeks of life the spot enlarges rapidly and a pulsating tumor of the subcutaneous connective tissue arises. A specially dangerous location for these growths is over the parotid gland, the vessels of which they may involve, so that extirpation of the gland may be rendered necessary. This, in infants, is a specially difficult and dangerous operation and is almost certain to be followed by facial paralysis of the corresponding side, owing to unavoidable injury of the branches of the seventh nerve.

Fig. 41.—Plexiform Neuromas of Arm (after Sutton).

1, Humerus; 2, musculospiral nerve; 3, supinator longus muscle; 4, neuroma; 5, neuromas on the cutaneous branches of the musculospiral nerve.

In the case of a young woman under my care an apparently innocent telangiectasis of the tragus and external ear assumed a most vicious and threatening aspect during the third month of pregnancy. The skin finally gave way and a most profuse hemorrhage took place, necessitating simultaneous ligation of the temporal, facial, and external carotid arteries, the latter beyond the occipital branch. In a subsequent pregnancy the phenomena returned, and it became necessary to remove the entire ear and ligate each vessel of supply separately. A cure was thus effected.

This form of nevus has, with some appearance of probability, been ascribed to a hereditary predisposition.

Cavernous nevus, or **erectile tumor,** occurs most frequently in the skin, where it forms a red or blue tumor elevated above the surface. Pulsation may be present. The cavernous structure consists of variously shaped spaces and sinuses together with some vessels. The tumor may be emptied of its contained blood, but if emptied it slowly refills. Cavernous nevi, as a rule, are congenital. They may enlarge rapidly and attain a large size, particularly in the breast of either male or female, and may even threaten life. They occasionally occur in the tongue, where they cause but slight inconvenience, as a rule, except for the accidental injury and the con-

sequent alarming hemorrhage to which they give rise and which may finally necessitate excision of the corresponding half of the tongue.

Cavernous nevi have been observed in the **voluntary muscles,** in the **larynx,** and, in a case of the author's, in the **broad ligament.** Small cavernous nevi have also been found in the **liver.**

Plexiform angiomas are comparatively rare. They comprise the tumors formerly called "aneurism by anastomosis" and "cirsoid aneurism." In structure they consist of moderately enlarged vessels arranged parallel to one another. Either arteries or veins may predominate in their formation, or the tumor may consist of both in about equal proportions.

A practical point in regard to telangiectatic, cavernous, and plexiform angiomas is the necessity for their destruction or excision on the first appearance of signs of activity and growth, in order to prevent them from assuming threatening or excessively dangerous proportions.

Fig. 42.—Macroglossia.

Lymphangiomas.—There are three species comprised in this genus, namely, (1) lymphatic nevus; (2) cavernous lymphangioma; (3) lymphatic cyst. Lymphangiomas consist essentially of the structural formation of lymphatics and bear the same relation to lymph-vessels as angiomas bear to blood-vessels.

Pure **lymphatic nevi** are, as a rule, colorless. They may, however, contain some blood-capillaries, in which case they appear as pale pinkish patches slightly raised above the level of the skin. Occasionally they are multiple. **Lingual lymphangiomas** occur as localized clusters of papillae consisting of dilated lymphatic vessels projecting from the mucous membrane of the tongue (macroglossia, Fig. 42).

Cavernous lymphangiomas, as the name implies, are identical in structure with cavernous nevi, their cavities, however, being filled with lymph instead of blood. Macroscopically they are not to be distinguished from lymphatic nevi.

Lymphatic cysts are easily recognized congenital cysts occurring either as unilateral or as bilateral growths. They affect by preference the anterior triangle of the neck, though they may be found in the middle line or may extend into the posterior triangle. In some instances they extend into the axilla and superior mediastinum. The cyst may be unilocular or multilocular, with or without intercommunication of the loculi. They originate beneath the deep fascia, but portions of the tumor may become subcutaneous. If the overlying skin becomes stretched and thinned by pressure from within—a not uncommon occurrence—the tumor may exhibit marked translucency. Their resemblance to hydrocele of the tunica vaginalis in this respect has led to the appellation "hydrocele of the neck."

These congenital cervical cysts have a special tendency to spontaneous

effacement, through either atrophic or inflammatory changes. In the latter case their disappearance is preceded by sudden increase in size, with the development of heat and tenderness. In the rare instances in which they have persisted until puberty and attempts have been made to empty the cyst, symptoms of collapse have followed (Birkett).

Endotheliomas.—This is a rare species of tumor, usually containing dilated lymphatics, and arising from the endothelium of lymph-vessels, and blood-vessels. They may infrequently attain a large size, are liable to degenerative changes, and exhibit a tendency to recurrence after removal. They arise in connection with the gums, in the mammary glands, in the skin in association with moles and warts, in the pleura, and in the cerebral and spinal dura.

Myomas.—Tumors composed of unstriped muscle-fiber are called myomas. They are of very rare occurrence, with the exception of uterine myomas, and are exclusively confined to localities in which involuntary muscle-fiber normally exists, such as the upper portion of the alimentary tract (the esophagus, stomach, and duodenum), the bladder, and the uterus. The similarity existing between unstriped muscle-fiber and the fusiform cells of sarcoma renders the differentiation difficult, and these difficulties are still further enhanced by the transverse striations sometimes observed in the spindle-cells of malignant tumors, and which are likewise observed in voluntary muscle in the embryonic stage. Tumors consisting of mature striated or voluntary muscle-fiber have not been observed.

EPITHELIAL TUMORS

In the study of epithelial tumors it is important to bear in mind that epithelium, the presence of which is the essential and distinguishing characteristic of this group, is widespread in its distribution and disposed in such a manner as to serve many and important functions. Wherever epithelium exists, whether as a protective covering, as in the case of the epidermis, or as the cellular lining of simple or complex glands or of their ducts, these epithelial tumors may arise.

The three genera of this group of tumors are (1) papillomas; (2) adenomas; (3) carcinomas.

Papillomas.—The most familiar example of a papilloma is the **common wart.** Warts consisting of overgrown papillae may occur in crops on the hands of children or about the anus and glans penis of patients with gonorrhea. A skin wart which persists and increases in size, particularly when it contains pigment granules, may ultimately become the point of origin of a melanosarcoma. Solitary soft red warts of rapid growth simulate malignant tumors. The surface cells of skin warts are sometimes converted into cutaneous horns. The mucous membrane of the **cheeks, nose,** and **larynx** may be the seat of warty growths similar in structure to those which occur on the skin. In the larynx they may produce suffocation.

Villous Papillomas.—The favorite seat of these growths is the mucous membrane of the bladder. They are occasionally observed in the renal pelvis. They may be either pedunculated or sessile. Structurally they consist of a delicate and very vascular connective-tissue body covered with epithelium. They are usually single, but they may be multiple. They may obstruct the ureter or urethra and not infrequently give rise to severe hemorrhage. Those occurring in the renal pelvis may exceptionally be associated with villous growths

in the bladder. Ulceration of renal and vesical papillomas causes a close simulation of malignant disease in these regions.

Intracystic villous papillomas are observed springing from the lining of cysts of the mamma (Fig. 43). These have the same structural characteristics as vesical papillomas. On section the cavity of the cyst contains a brownish colored fluid, the result of hemorrhage from the villous growth. When the cyst is formed of a galactophorous duct, this same brownish fluid may be discharged at times from the nipple.

Psammomas are confined exclusively to the pia mater of the brain and spinal cord and are of slight surgical interest.

Cutaneous Horns.—These may form in situations where sebaceous glands exist (**sebaceous horns**); as wart horns on the penis or pinna; as cicatrix horns springing from a scar left by a burn; or as nail horns on the toes of bedridden patients and elderly unclean individuals.

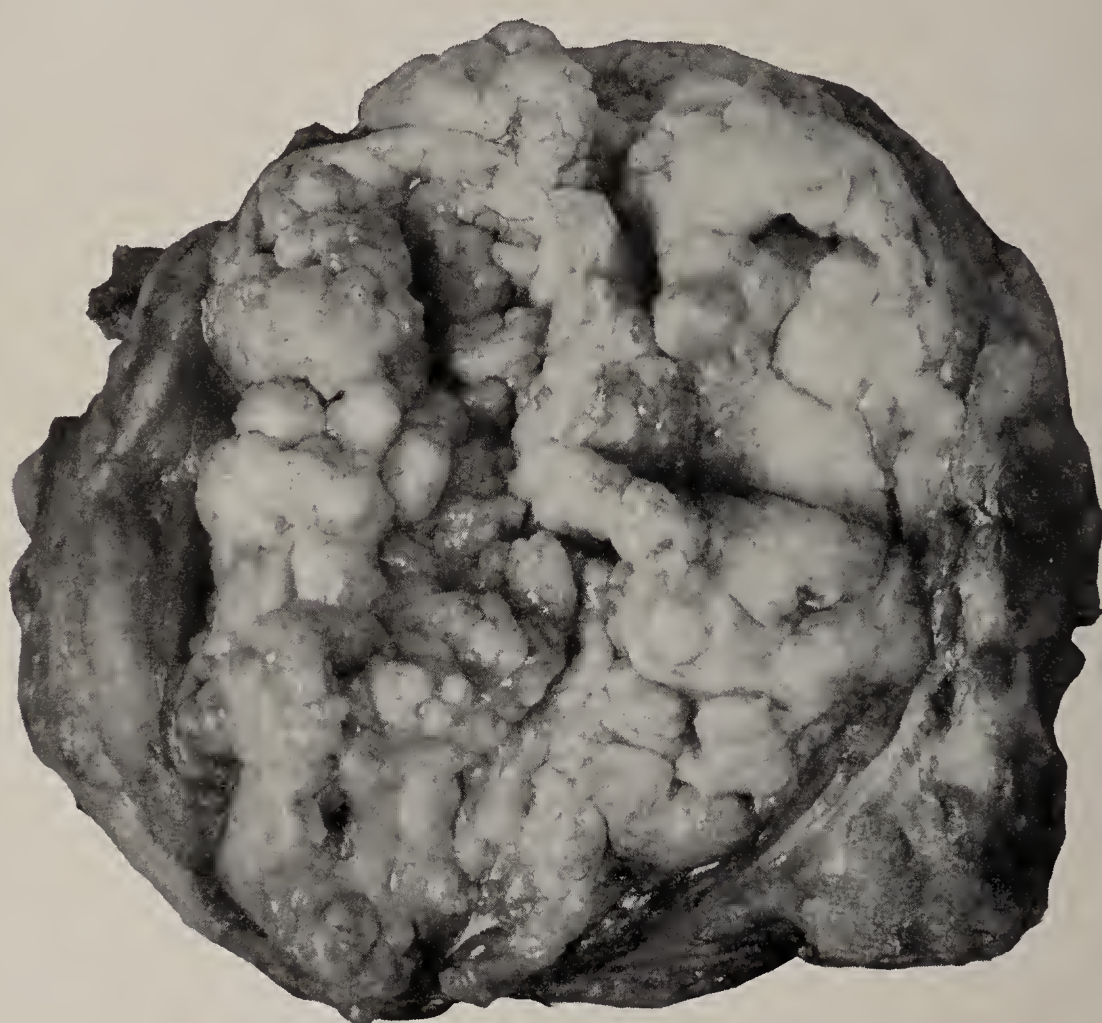


Fig. 43.—Intracystic Papillomas of Breast.

Adenomas.—A tumor arising from the epithelial elements of a secreting gland is called an adenoma. The principle of its construction is typic of secreting gland tissue, namely, narrow channels lined with epithelium, with a connective-tissue basis containing blood-vessels. In some examples the epithelial element greatly predominates, while in others the disproportionate amount of connective tissue present is suggestive of sarcoma (**adenosarcoma**).

Adenomas occur as encapsulated growths in the mamma and liver, and in large secreting glands, such as the parotid and thyroid. In the glandular structure of the mucous membranes they occur as pedunculated growths. They occur singly or as multiple growths springing from the same gland. They vary greatly in size. They may be found in a child's rectum as pedunculated growths as small as a pea; in the breast of a woman they will occasionally grow

to the size of a large cocoanut. When multiple, they are likely to be small, while solitary growths are frequently large.

These growths do not affect lymphatic glands nor cause secondary deposits, and when thoroughly extirpated they do not recur. The dangers of their presence arise principally from mechanic disturbances. The frequency with which these tumors coexist with carcinomas in the same gland has given rise to the erroneous belief that they may be transformed into cancers.

A **cystic adenoma** is present when the epithelium-lined spaces of the growth are filled with fluid. The latter, however, is identical with the normal secretion of the gland from which the growth springs. This variety is found most frequently in the mamma, where it is sometimes in communication with a galactophorous duct. Under these cirumstances the fluid can be expressed from the nipple and constitutes a valuable diagnostic sign.

Fibroadenomas affect particularly the breast. They occur as almond-shaped growths affecting the upper, outer, and lower quadrants specially. Their size varies, but it is not rare to find them larger than an English walnut. They are most commonly found after the age of puberty. They are usually situated in the superficial portion of the gland, though they may be deeply placed. They are not infrequently multiple and it is not unusual to find both breasts the seat of these growths.

Complex adenomas have been observed in the mamma, combining the fibrous structure of the fibroadenomas and numerous and large cysts. The latter are sometimes the seat of intracystic growths. The cyst, under these circumstances, corresponds to a dilated galactophorous duct. These tumors are distinctly isolated from the remainder of the gland by a capsule and may attain a large size.

Sebaceous adenomas are growths springing from the sebaceous glands and presenting the usual clinical signs of wens. On section, however, they are found to be composed of lobules which represent an overgrowth of a sebaceous gland. These growths ulcerate frequently, the ulceration being accompanied by a fetid discharge; they then constitute one of the varieties of "fungous wen."

Sebaceous cysts or **wens** are collections of sebum in sebaceous glands. They are generally believed to arise from obstruction of the orifice of the follicle and distention of the acini, an appreciable swelling resulting. This explanation, however, will not suffice for even a majority of the cases, inasmuch as obstruction is more frequently absent than present. The tumor comprises a capsule and its contents, the latter consisting of pultaceous material mixed with epithelial scales. Calcification sometimes occurs. The cysts may occur in the skin covering any portion of the body except the limbs, but their favorite location is the scalp and the external genitals. They vary in size from a pea to a small orange.

The contents of these cysts are liable to decomposition, when a peculiar and extremely offensive odor is evolved. Inflammatory conditions of the cyst wall also occur, particularly when the cysts are situated in parts exposed to injury. When inflamed, they are a deep purplish-red color. Suppuration may take place. Simple incision, as a rule, does not suffice for a cure, a portion or all of the cyst wall remaining and leading to the formation of fistulas or the reproduction of the entire tumor.

Adenomas of the thyroid constitute the basis of one of the forms of goiter. They occur as encapsulated tumors in one or both lobes of the gland, vary greatly in size, and contain vesicles of the same character as the thyroid gland itself. Coalescence of the vesicles occurs coincidentally with the disappearance of the septa, and in this manner a **cystic bronchocele** is formed. The cavity of a cyst thus formed contains fluid, the result of intracystic hemorrhage. The fluid itself often contains cholesterin. Colloid material may be present (colloid struma). Very rarely papillomas may be found springing from the walls of the cyst.

A cystic bronchocele may attain large proportions, causing pain and giving rise to dyspnea from pressure on the trachea in cases in which the tumor descends behind the episternal notch. When the descent is in front of the sternum, the growth is sometimes very mobile.

Adenomas of the liver when fully developed occur as spherically shaped and encapsulated tumors, varying in size from a hazelnut, when they are single, to a small orange, when they are multiple. They may be situated in almost any portion of the liver. They may be a bright green in color, due to the presence of bile, or a dull white. They are made up of solid columns of cells at the periphery of the tumor with a lumen in the center. In a case operated on by the author the growth presented to the naked eye a striking resemblance to carcinoma.

Prostatic adenomas consisting of enlarged glands in the prostate are of not infrequent occurrence late in life. The organ becomes increased to two or three times its normal size, and this increase in size, when it occurs in connection with the collection of glands situated posteriorly to the verumontanum, may cause a projection into the lumen of the urethra. The patency of the vesico-urethral orifice is thus interfered with, and urinary obstruction with its attendant and consequent evils follows.

Carcinomas.—Malignant neoplasms arising in epithelium are called carcinomas, or cancers. A malignant tumor springing from a free surface covered with epithelium of the squamous or pavement variety is called an epithelioma. When the growth originates in the epithelium of a gland, it is known as glandular carcinoma.

In spite of the widespread distribution of the epithelial elements from which carcinomas arise, the disease shows a special predilection for certain localities, and is rarely found in others.

The special histologic characteristic of carcinoma consists of the presence of columns of cells, which on section present under the microscope the appearance of a number of alveoli. The walls of these alveoli are composed of fibrous tissue in which blood-vessels and lymph-vessels ramify, and the spaces are filled with epithelium (Fig. 44). The cells comprising the columns partake of the character of those from which the growth originates. The amount of fibrous tissue in the walls of the columns as seen under the microscope will vary greatly between the hard and the soft variety.

The Infiltration of Carcinoma.—The dangers arising from the presence of carcinoma, as well as the difficulties of dealing with it surgically, are greatly enhanced by the inability of even the skilled pathologist, with the aid of the microscope, to define the dividing line between the diseased tissues and the surrounding healthy structure. This infiltrating property of carcinoma leads to the rapid involvement of adjacent parts, whether skin, fat, mucous mem-

brane, or bone, is a very common cause of death, and only too often proves an insurmountable barrier to successful surgical intervention.

Glandular Infection.—The free distribution of lymph-vessels on the surface of the body and within the secreting glands which are derived from this surface forms the basis for a free communication between epithelial growths and the lymphatic glands, and for the consequent infection of the latter when carcinoma is present. Lymphatic glands thus infected may attain many times the size of the original growth. The readiness with which lymphatic glandular infection arises varies with the susceptibilities of the individual, as well as with the anatomic peculiarities of the part affected. A lack of knowledge of the extent of the lymphatic glandular infection renders the prognosis after operation very uncertain.

Dissemination.—In addition to the infiltrating and lymphatic-infecting properties of carcinomas, their malignancy is still further emphasized by their proneness to dissemination. This dissemination occurs through the medium of secondary deposits which have their origin in minute portions of cancer tissue. They may find lodgment in any of the organs or tissues of the body, may be transported as emboli by the lymph-vessels and blood-vessels and deposited in situations where in due course of time they proliferate; a tumor then arises, which has exactly the same histologic features as the primary growth. When the dissemination is widespread, and particularly when such organs as the globe of the eye, ovaries, brain, and vertebrae are the seats of secondary deposits, it is an indication that emigration of the cancer emboli has taken place through the general systemic circulation.

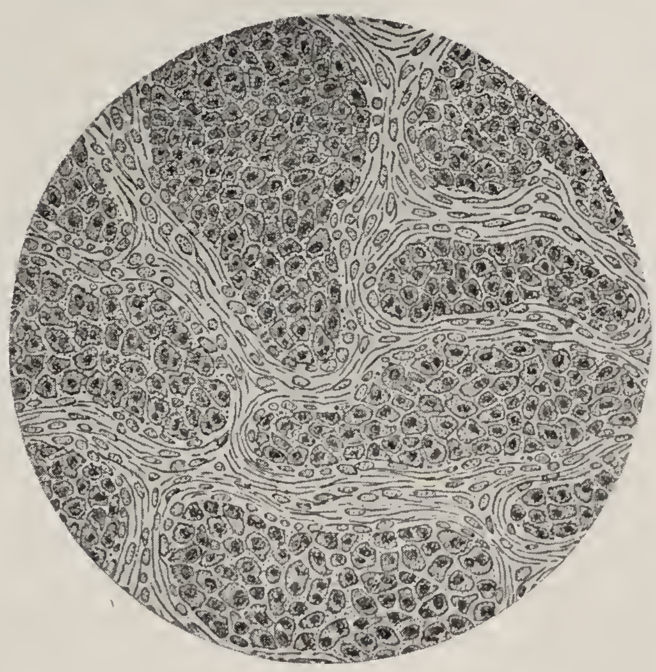


Fig. 44.—Carcinoma of the Mammary Gland.

Disseminated infection may also take place without the aid of lymph-vessels or blood-vessels, as in the case of diffused nodular carcinoma of the peritoneum. Under these circumstances the original focus of disease resides in an abdominal viscus, the implicated peritoneal covering of which gives way, so that the epithelial elements of the tumor are scattered about in the peritoneal cavity through the peristaltic movements of the intestines, and the peritoneal fluid.

Degenerative Changes.—The absence of a free blood-supply to epithelial growths leads to retrograde changes in carcinomas, the chief of which is that known as colloid degeneration. In colloid degeneration the epithelial cells making up the columns of the carcinomatous structure undergo certain changes which result in a jellylike transformation of the cells. These changes may take place so rapidly and completely in certain situations, such as the ovary, the stomach, and the breast, that cancerous growths in these organs are frequently referred to as "colloid carcinomas." The condition, however, is simply one of degeneration of the common type of glandular carcinoma.

The **infective properties** of carcinoma are now fairly well established. This is not a matter of surprise when the readiness with which epithelial ele-

ments grow when accidentally engrafted is considered. The most important bearing which this infective character has in the work of the practical surgeon relates to the care that should be exercised in operations for the removal of carcinomatous growths to prevent the surfaces of the wound from being sown with the diseased cells.

The Etiology of Carcinoma.—The special predilection of cancerous growths to attack those glandular structures which have a more or less direct communication with the outer world, such as the mammae, the stomach and rectum, as well as those which arise directly from the skin surface, has suggested a parasitic origin for the disease. The subject is, however, still under investigation, and must at the present time be considered *sub judice.*

While there are reasons for believing that certain congenital local predispositions to the disease exist (moles, nevi, fleshy warts, etc.), yet it should not be assumed that either these or chronic inflammatory lesions are the necessary antecedents of cancer. Traumata have also been considered as being efficient causes of the affection. A careful study of the statistics, however, disproves this view (Williams).

Epithelioma.—Squamous-celled carcinoma, or epithelioma, occurs on surfaces covered with stratified epithelium, particularly at those points where skin and mucous membrane merge into each other. Familiar examples of the latter tendency are found in the lip, the vulva, and the anus. The disease arises as a prominent isolated growth resembling a wart, as a small ulcer with well-defined and infiltrated margins, and as a fissure with more or less firm edges.

The histologic characteristics of epithelioma are similar to those of glandular carcinoma, the surface epithelium invading the growth, or the ulcer and its infiltrated margins, in the shape of columns, the cells of which retain to a greater or lesser extent the characters of the epithelium from which they spring. Epithelial pearls are formed by the cornification of the flattened cells in rapidly growing cellular cones. Parts that are the seat of already existing disease are apparently more liable to be attacked by epithelioma. As examples of this may be cited the tongue (leukoplakia and old syphilitic ulcers), the vulva (leukoplakia), and chronic ulcers of the leg. Disturbances of nutrition due to the presence of scars resulting from burns, as well as lupus scars, also appear to increase the liability to epithelioma.

The more vascular the structures adjacent to a breaking down epithelioma, the more rapidly the infiltration and ulceration extend. Cartilage, for instance, is quite exempt from invasion. Occasionally the fungous properties of the ulcer predominate, and the infiltration and peripheral ulceration proceed more slowly. In whatever structure or situation the disease occurs, however, it rapidly destroys life. When the disease involves large blood-vessels, these are opened, and death from hemorrhage often takes place. In parts remote from large vessels, as in the breast, death occurs from septic and anemic conditions combined (cachexia). Death from inhalation pneumonia is not infrequent in cases in which the cancerous growth is adjacent to the air-passages and septic material is inspired.

Lymphatic glandular infection is the most serious danger which threatens patients with epithelioma, because of the promptness with which this occurs, the size which the glands attain, and the difficulty in completely removing these. This is particularly true of cases of epithelioma of the tongue, the lip, the scrotum, and the penis.

Dissemination.—The extent to which this occurs bears some relation to the seat of the disease. This is due in part to the fact that in some situations, as, for example, the larynx, life is destroyed before opportunity is afforded for dissemination. On the other hand, this does not hold good in other situations in which destruction of life is sometimes delayed, gland infection being extensive, yet dissemination quite exceptional, as, for instance, epithelioma of the scrotum.

Treatment.—Clinical experience with epithelioma, as in the case of all forms of malignant disease, emphasizes the supreme importance of early and complete operative removal of all implicated structures.

DERMOIDS

The special and characteristic feature of the group of tumors to which the term "dermoid" is applied, as the name indicates, is the presence of skin and mucous membrane in the growth. In the neoplasms thus indicated the skin or mucous membrane is formed in situations where these structures do not exist under normal conditions. No other tissues enter into their composition.

Four genera are assigned to this group, as follows: (1) sequestration dermoids; (2) tubulodermoids; (3) hairy moles; (4) ovarian dermoids.

Sequestration Dermoids.—These constitute the simple form of this group. As the name implies, they arise in isolated or sequestrated portions of skin, usually in the lines of embryonic coalescence. A dermoid may be a simple skin-lined recess; the usual form, however, is that of a globular tumor with a central cavity the lining of which possesses the dermal elements of true skin.

Dermoids of the Face.—These occur in situations representing the site of the facial fissures in the embryo. They are found most frequently (1) at the outer and inner angles of the orbit; (2) in the upper eyelid; (3) in the nasofacial sulcus; (4) as dermoid recesses or sinuses at the site of the internasal fissure.

Dermoids of the scalp occur most frequently over the anterior fontanel and at the occipital protuberance. In either of these situations they may be mistaken for wens or meningoceles. Dermoids have also been found connected with the dura mater, a circumstance which finds its morphologic explanation in the fact that the skin and dura remain practically in contact at the sites of the cranial sutures, even for a year or more after birth, particularly in the neighborhood of the bregma and inion, and a failure of ultimate separation as the bone fissure closes may give rise to a dermoid.

Dermoids of the trunk occur strictly in the regions where the lateral halves of the body join each other, namely, on the line commencing at the upper limit of the cervical vertebrae, extending along the middle line posteriorly, and thence through the perineum and upward anteriorly to the middle of the lower lip. Dermoids are rare along the dorsal portion of this line, with the exception of sacral cysts and coccygeal sinuses. The latter are recesses lined with skin and running almost parallel to the surface. The small external opening lies at the bottom of a so-called postanal dimple. Hair and dirt accumulate in the sinus and suppuration may occur. A sinus of this kind may be mistaken for an anal fistula.

Dermoids of the thorax are very rare. They may occur either at the anterior aspect of the sternum or within the chest itself. Only the former are of

surgical interest. They are situated near the junction of the manubrium with the gladiolus, at the site of a small dimple or recess in the skin sometimes found in this situation. A dermoid develops, though rarely, in the episternal notch.

Dermoids of the Scrotum, Testicle, and Labium.—Dermoids of the scrotum have been found in such close relation to the testicle that they have been reported as arising from the latter. It is probable, however, from a morphologic standpoint, that dermoids of the testicle are very rare as compared with those occurring in the scrotum. Dermoids of the labium are very common. In a case operated on by the author the growth, which externally was only the size of a small orange, was found to have burrowed deeply into the thigh. A similar case is mentioned by Sutton.

Implantation cysts are of interest in connection with the study of dermoids. They result from the accidental implantation of portions of skin or of some of its elements (epithelium, hair-bulbs, etc.) into the subcutaneous connective tissue, where they become engrafted and proliferate, a cyst resulting. These are sometimes called "traumatic dermoids." They may grow to the size of a hazelnut. Similar cysts of traumatic origin have been found on the iris and cornea.

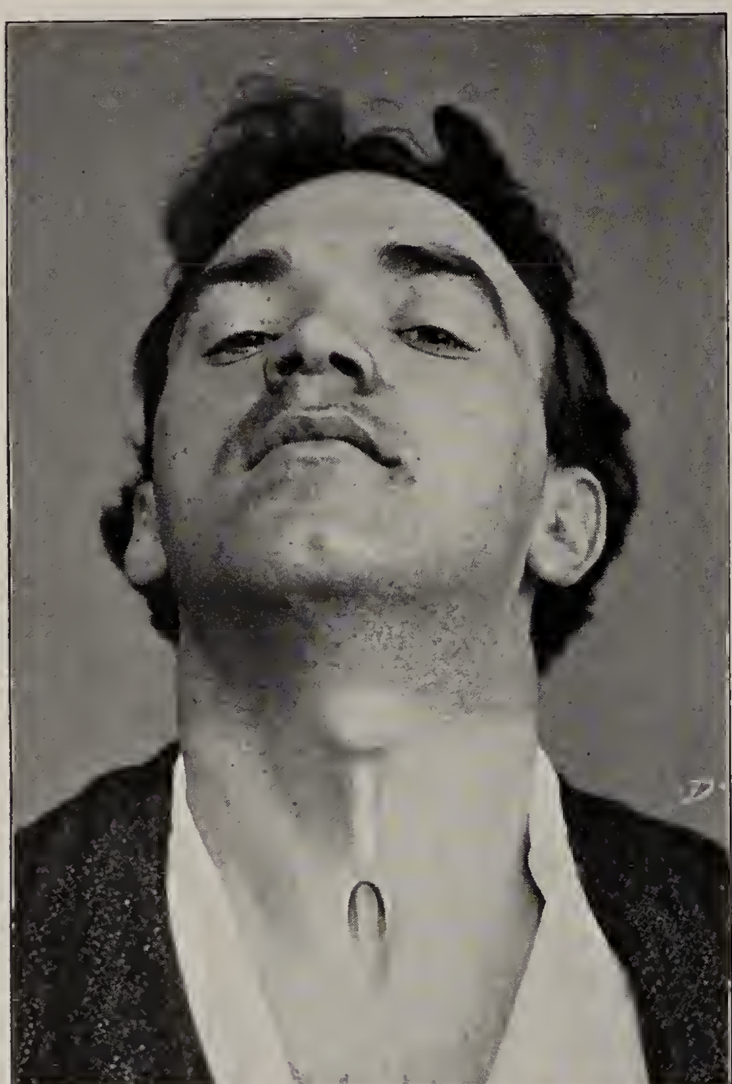


Fig. 45.—Median Cervical Fistula Associated with a Persistent Thyroid Duct.

Tubulodermoids.—These arise in connection with one of the embryonic canals which fail to disappear normally at birth. Those which may remain more or less persistent after birth and which are of special surgical importance in this connection are (1) the thyroglossal duct; (2) that portion of embryonic intestine extending behind the anus called the postanal gut; (3) the branchial clefts.

The thyroglossal duct is a median offshoot from the ventral wall of the embryonic pharynx, from which the isthmus of the thyroid is derived. In the embryonic state the duct extends as far upward as the base of the tongue and bifurcates laterally in the direction of each rudimentary lobe of the thyroid. Its persistence assumes a surgical interest in connection with (1) lingual dermoids; (2) median cervical fistulas; (3) accessory thyroids.

Lingual dermoids arise in the tongue and occupy a central position in that organ, between the geniohyoglossi muscles. They originate in the lingual portion of the thyroglossal duct, the upper end of which has become obliterated. These tumors vary greatly in size; they may become large enough to interfere seriously with the taking of food.

Median Cervical Fistulas (Fig. 45).—These originate as retention cysts

formed in a persistent thyroid duct, or that portion of the thyroglossal duct below the hyoid bone. A median swelling in the neck commonly precedes the occurrence of glairy or mucous discharge, after which there is a persistent sinus. The site of this sinus is often marked by a cordlike process extending up to the hyoid bone. The lower end of the fistula usually terminates in a thin-walled sac opening on the free surface of the skin. Upon dissecting out this sinus the upper end may be found to be obliterated and firmly attached to the hyoid bone. The sinus may also be bifurcated, following the course of the duct in the direction of the lobes of the thyroid. The lingual duct, or that portion above the hyoid bone, may persist to the surface of the tongue (Fig. 46).

Median and lateral accessory thyroid bodies may occur as remnants of the thyroglossal duct.

Dermoids of the Rectum.—These occur in connection with the embyronic postanal gut, which also gives rise, in all probability, to the congenital sacrococcygeal tumors occasionally observed. The variety of dermoid sometimes found between the hollow of the sacrum and the rectum (**postrectal dermoids**), which may attain large dimensions and extend upward behind the pelvic peritoneum, also has its origin in this obsolete canal. These growths sometimes contain both teeth and hair and may open spontaneously in the perineum.

In addition to the above described postrectal dermoids, these growths have been found growing from the mucous membrane of the rectum as pedunculated tumors (**rectal dermoids**). They may protrude from the anus and simulate either rectal polypi or hemorrhoids. They may contain hair and teeth; the former is in the shape of long locks. Dermoids in this situation should not be confounded with ovarian dermoids, which sometimes open and discharge into the rectum.

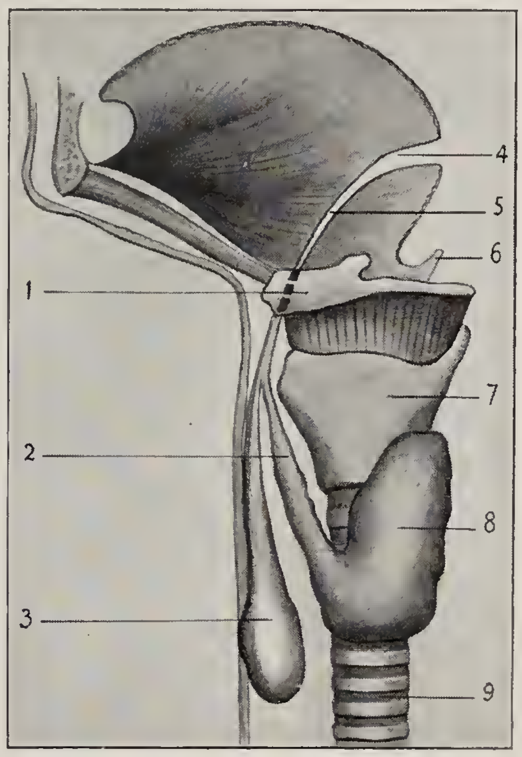


Fig. 46.—Median Cervical Fistula. (Diagrammatic, showing the Relation of the Parts.)
1, Hyoid bone; 2, pyramid of thyroid; 3, abscess sac; 4, foramen caecum; 5, lingual duct; 6, epiglottis; 7, thyroid cartilage; 8, thyroid gland; 9, trachea (from Sutton, after Marshall).

Branchial fistulas and cysts have their origin in either one or more of the four embryonic branchial clefts of the human fetus. The partial or complete persistence of one or more of these clefts results in **congenital cervical fistulas** (Fig. 47). These may open on the skin surface of the neck or in the pharynx; or they may exist as complete fistulas. The site of the external orifice is sometimes marked by a tag of skin containing yellow elastic cartilage (**congenital cervical auricle,** *vide infra*). The fistulas may be single or multiple and lined with skin or mucous membrane. They are occasionally the seat of suppuration with the formation of an abscess.

The persistence of the portion of the cleft between the internal and the external orifice results in an unobliterated branchial space, a true retention dermoid cyst arising. This cyst may contain mucus if the external portion is obliterated, and the sac lined with mucous membrane continuous with that of the pharynx; or if the internal segment of the cleft is obliterated, the sac being

continuous with the epithelial structure of the skin, the cystic dilatation will be filled with epidermal scales, sebaceous matter, and cholesterin. In the experience of the author the latter is the more common variety. Those obliterated externally but opening internally may occur as diverticula of the pharynx.

Cervical Auricles.—A hereditary influence is claimed for the origin of these appendages. Both structurally and morphologically they are identical with the normal auricle or pinna, and consist of yellow elastic cartilage and muscle fiber from the platysma, covered with skin. They may or may not be associated with cervical fistulas, but when present are always situated in the locations affected by the latter.

A congenital fistula sometimes appears leading into the substance of the helix (**auricular fistula**). These are deemed hereditary and may coexist with branchial fistulas. They are sometimes found in the lobule.

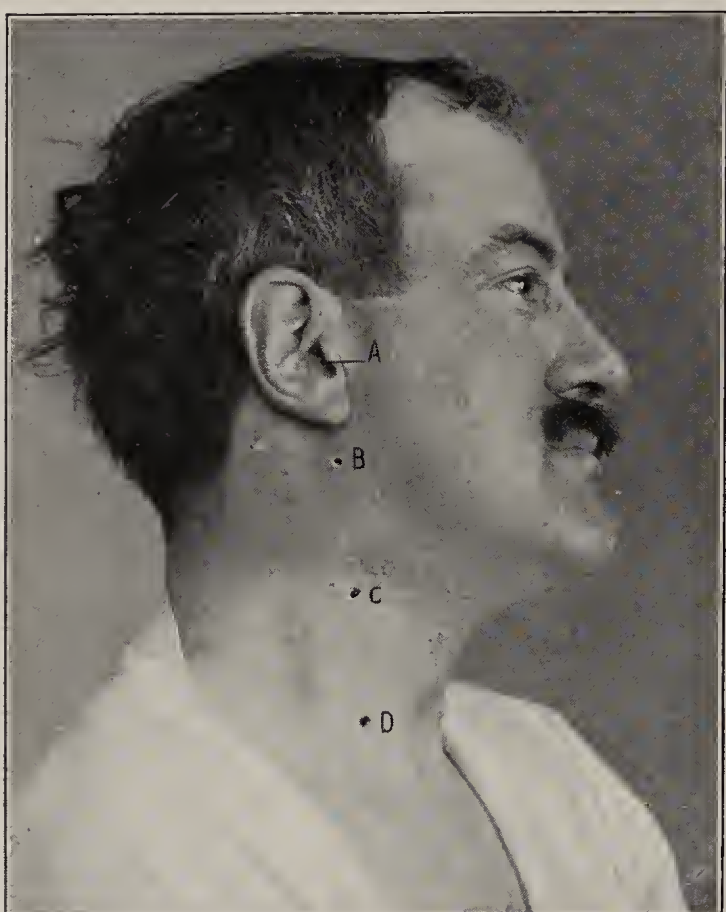


Fig. 47.—Congenital Fistulas, showing Orifices of Persistent Branchial Fistulas.

A, Tympano-Eustachian passage; B, opening close behind the angle of the jaw, and anterior to the line of the sternomastoid muscle; this opening is sometimes found on a level with the lobule of the pinna and slightly posterior to it; C, this opening occurs very constantly in the situation here shown, *i. e.*, on a level with the thyroid space, close to the anterior border of the sternomastoid; D, this fistula usually opens near the sternoclavicular articulation; it may vary somewhat in its relations with the latter, but its position relative to the sternomastoid muscle is rather constant.

Auricular dermoids arise in unobliterated skin-lined spaces left between the tubercles uniting to form the auricle. They sometimes occupy the groove between the pinna and the mastoid.

Reduplication of the tragus sometimes occurs (**accessory tragus**). It may occur as a conical projection or as a pedunculated process of skin covered with hair. It is occasionally associated with defects in the mandibular fissure.

Moles.—The dermoid patches known as moles are pigmented and slightly raised above the level of the skin. They are usually covered with hair. They are very vascular and bleed easily if injured, or in case of ulceration, to which they are liable. The tissue immediately underneath moles is arranged in alveoli, such as are found in sarcomas occurring in connection with these growths (alveolar sarcomas). In fact, the surgical interest manifested in these usually innocent tumors is centered in the fact that later in life they are liable to become the starting-point of one of the most malignant forms of sarcoma, namely melanosarcoma.

Moles may be single or multiple, they are sometimes very sensitive, particularly those which occur on the trunk. They may occur on the conjunctiva, where they are sometimes associated with the embryonic defect of the eyelid known as coloboma.

Teratomas are certain irregular and conglomerate masses formed almost exclusively in connection with the vertebral column and skull, and containing

the tissues and portions of viscera belonging to an immature and suppressed fetus. They occur in individuals otherwise normal and include conjoined twins, supernumerary limbs, and acardiac parasitic fetuses. They are mentioned in connection with the surgical study of tumors because of the liability of confounding irregularly shaped tumors with dermoids.

CYSTS AND PSEUDOCYSTS

Cystomas are tumors resulting from the abnormal dilatation of pre-existing tubules or cavities. They may be divided into (1) retention cysts; (2) tubulocysts; (3) hydroceles.

Retention cysts, as the name implies, result from the obstruction of the duct of a gland and the accumulation of fluid within the ducts and acini. When the obstruction is permanent, the gland atrophies and is replaced by fibrous tissue, of which the walls of the simplest form of cysts are composed.

The purest form of cyst occurs in connection with hollow organs, the inner walls of which are provided with glands. In the case of the gall-bladder the obstruction may be due to impacted gall-stones, a pancreatic concretion, tumors, etc., and may occur in the cystic duct, in the common duct, in Vater's diverticulum, or in the wall of the duodenum at the site of the latter. When the obstruction is complete and permanent, the gall-bladder may atrophy if the obstruction is in the common duct, or become greatly distended with mucoid fluid, the result of cholecystitis, if the cystic duct is the seat of the obstruction (**dropsy of the gall-bladder**); suppuration may follow (**empyema of the gall-bladder**).

Pseudocysts.—The conditions known as diverticula and pseudocysts are conveniently treated of in this connection. They include the intestinal, vesical, and pharyngeal diverticula, the hernial protrusions of synovial membrane from cavities of joints known as synovial cysts, and a similar condition occurring in connection with the synovial lining of a tendon-sheath, known as ganglion. Adventitious bursae are also to be classified with pseudocysts. (For intestinal, vesical, and pharyngeal diverticula see Regional Surgery, Part II.)

Tubulocysts.—These occur in the so-called functionless ducts, such as the vitello-intestinal duct, the urachus, and the remains of the mesonephron (Wolffian body). Those of special interest to the general surgeon occur in connection with the above mentioned. (See Regional Surgery, Part II.)

Synovial Cysts.—These may occur as (1) hernial protrusions of the lining of a joint; (2) bursae in the neighborhood of joints; (3) hernial protrusions of the synovial covering of tendons. The first have been frequently observed in connection with the joints of the hip, knee, ankle, shoulder, elbow, and wrist. Those which have aroused the greatest surgical interest have occurred in connection with the knee-joint, where they have been found in relation with the biceps, the semimembranosus, or the heads of the gastrocnemius muscle. Cysts have been found at some distance from the joints from which they arise, communication being maintained by a very narrow channel. They are liable to arise in tuberculous joints and are due to increased intra-articular tension, the synovial membrane being forced through weak spots in the joint capsule. Normal bursae in the neighborhood of joints may become enlarged and establish a communication with the joint cavity. Synovial cysts connected with the knee-joint are likely to find their way either to the popliteal space, to the

middle of the calf just below the latter, or to the inner side of the leg below the head of the tibia.

It may be said of these cysts in a general way as they occur in the other localities named, that they will force their way as synovial projections from the joints at the points where the latter are least protected by overlying muscular structures, and thereafter pass in the direction of least resistance along the intermuscular planes. Or they may be guided by the margins of a sharply defined tendinous structure, as, for instance, the long head of the biceps in the case of a synovial cyst of the shoulder.

The cyst contents may be clear synovial fluid, or in the case of diseased joints it may be turbid and contain pus-cells; or true pus may be present.

Ganglion.—The cyst wall of a ganglion consists of the synovial lining of a tendon-sheath which has escaped from its normal environment.

In the variety known as **simple ganglion** the cyst appears as a rounded, elastic, sessile swelling. A rather common situation for these cysts is the back of the carpus. Many of these, however, on dissection prove to be diverticula from a carpal joint, from which it is often exceedingly difficult to differentiate them. In addition to the above named familiar location, simple ganglions are met with in the sheaths of the long flexors of the fingers, on the dorsum of the foot, and on the outside of the ankle. The fluid contents resemble grape jelly.

Compound Ganglions.—These occur more frequently in connection with the flexor and extensor tendons of the carpus, more rarely on the tendons of the peronei.

This variety of ganglion is of far greater surgical importance than the foregoing. Extension takes place for variable distances, and unexpectedly wide dissections are sometimes necessary in following the prolongations of the cyst, which may pass under the annular ligament, both anteriorly and posteriorly, to find their way into the palm or along the extensor tendons. Crepitation felt in these ganglions is due to the presence of so-called "melon seed" bodies.

Both varieties are likely to recur after operation, even when every vestige in sight has been carefully dissected out. In the case of the simple ganglions, this is due to the fact that, though they burrow in and between the tendons, they really spring from the wrist-joint; in the case of the compound ganglions, to the fact that many of them are tuberculous in origin, the most radical measures sometimes being inefficient to destroy the extensive infective process, so that after repeated recurrences amputation becomes necessary.

Bursae.—Bursal sacs may form in any part of the subcutaneous connective tissue where the overlying skin is subjected to intermittent pressure. They may occur in any portion of the body where muscles and tendons glide over osseous surfaces or in situations where the skin lies in close contact with bony prominences. They are normally present in certain situations, as, for instance, in front of the patella and behind the olecranon. **Adventitious bursae,** on the other hand, arise in situations where the results of pressure are a pathologic rather than a physiologic sequence of anatomic conditions, such as in clubfoot, bunions, etc. **Subtendinous bursae** sometimes communicate with the sheath of the tendon and occasionally with the cavity of a neighboring joint.

Bursal sacs are thin walled with smooth inner surfaces, in which, as a rule,

epithelium is wanting. They contain a glairy fluid and sometimes loose bodies. Their formation is believed to be brought about by the rupture of connective tissue between the movable overlying skin and the solid prominence beneath. This at first imperfectly isolated space finally assumes definite boundaries and the condensed connective tissue becomes a smooth sac wall. These sacs may occur in any situation where pressure is exercised, and hence bear a close relationship to the occupation of the individual. The most frequent forms are **"housemaid's knee," "miner's elbow,"** and **bunion.** The first occurs in persons whose occupation or habit leads to more or less constant kneeling. The second is common in those whose occupation in close quarters, as in mining, leads to frequent blows on the elbows. The third usually results from wearing ill fitting shoes, and is the condition commonly observed over the enlarged head of the first metatarsal bone in hallux valgus.

Bursae are subject to inflammatory conditions (bursitis), either acute or chronic. An acutely inflamed condition demands complete rest of the parts. Accumulations of fluid may occur, requiring either systematic pressure to produce absorption or incision for their evacuation. Suppurative changes are not uncommon. An inflamed bunion may involve the underlying joint and demand excision of the latter or even amputation of the toe.

The **thyrohyoid bursa,** or that lying between the hyoid bone and the thyrohyoid membrane, is sometimes the seat of considerable enlargement and may require incision and drainage.

THE DIAGNOSIS OF TUMORS

Even the existence or the nonexistence of a tumor is sometimes difficult of affirmation. This is particularly true of neoplasms in the brain and spinal cord. Dr. Charles K. Mills, of Philadelphia, has recently called attention to the Röntgen ray method in the diagnosis of intracranial neoplasms. Tumors of the abdominal and pelvic cavities sometimes require very close attention and careful watching to eliminate the possibility of an accumulation of intestinal contents, contractions of isolated portions of muscular structures (phantom tumor), the existence of normal and ectopic gestation, etc., as sources of error. In the case of neoplasms easily palpated, as well as in most of the more obscure examples in which both subjective and objective symptoms are sometimes contradictory and misleading, the question of differential diagnosis will frequently present many difficulties. The history, age of the patient and length of time of the existence of the tumor, its rate of growth, its gross physical characters and situation, its freedom of movement or attachment to surrounding and overlying structures, its relations to these, the question of lymphatic involvement or visceral complications, the presence of metastases, the microscopic characters of sections removed for examination in the differentiation of benign and malignant growths, the results of exploratory operation and the outcome of therapeutic tests in the exclusion of syphilitic lesions—all these are of the greatest importance in connection with the diagnosis of neoplasms.

TREATMENT OF TUMORS

In a general way it may be stated that the only trustworthy method of dealing with a tumor is to effect its removal or destruction. There can be no two opinions as to the advisability of promptly attacking any malignant growth, and removing it, together with as much of the surrounding structures as safety will permit. Amputation of a part involved in a malignant growth should always be given the preference over simple excision. Benign tumors may be removed whenever they become a source of annoyance, inconvenience, discomfort, or deformity. In the event of their becoming a source of ill health even to a slight extent, or a menace in the future, their removal is demanded.

SECTION VII

LABORATORY AIDS IN SURGICAL DIAGNOSIS AND PROGNOSIS

The use of laboratory procedures as practical aids in the diagnosis and prognosis of disease is comparatively modern, and their value has become so important that a consideration of their significance and of the detail of their technic has earned a place in every text-book.

Successful surgery demands prompt and accurate diagnosis, and to this end laboratory examinations frequently offer conclusive proof or corroborative evidence of much value. With the great advances in surgical skill and the consequent improved statistics of surgical procedure, the question of prognosis has also become more important, and laboratory aids form no mean part in reaching conclusions in this regard. The brilliant outcome of laboratory diagnostic methods in some cases may lead the novice to attempt to make a definite diagnosis with the microscope and test-tube at the expense of clinical methods. This is a grave error—the diagnosis must be made at the bedside, and the results of laboratory work considered for what experience teaches they are worth, just as the clinical signs and symptoms are considered.

Pathologic, bacteriologic, and chemic technic must be shorn of every detail not absolutely necessary, in order to commend itself to the busy practical worker, who is interested solely in the result, and not in the method of investigation. The surgeon seeks aid in diagnosis and prognosis; he is interested in the outcome of the laboratory help, and the methods that meet with his approval are those which are easily and quickly executed, often at the expense of absolute accuracy, as long as they are sufficiently precise to meet clinical practical purposes.

The research laboratory worker should be a scientist; for him absolute accuracy is the keynote of success, without which his results merit no confidence. He must modify his absolutely accurate method, in order that it may appeal to the clinician as a practical procedure, the results of which justify the work required. This demand, being of comparatively recent date, has not had the attention from teachers that it deserves, as the following examples will illustrate: Teachers and text-books advocate the spreading on the thin microscopic cover-glasses of sputum, pus, blood, or any other substance which is to be dried on a carrier for subsequent staining. These small films of glass are difficult to handle, are easily broken in the manipulation of staining, washing, and drying, and present a limited surface for investigation. The microscopic slide should be used for this purpose. Its advantages are obvious. A chemic procedure often presents the details of complex graphic formulas of not the slightest interest to the practical worker, while the specific directions given for the test are so lax as positively to invite error.

The following is a brief summary of the examinations useful in surgical diagnosis and prognosis, with a description of the technic in the more important ones:

Pathologic examinations.
Bacteriologic examinations.
Chemic examinations.
Specific examinations: Blood. Urine. Sputum. Gastric contents. Aspirated fluids.

PATHOLOGIC EXAMINATIONS

The following remarks must necessarily be limited to the preservation and preparation of specimens for examination, whereas the descriptions of the different gross and microscopic pathologic tissue changes met with in surgery are detailed elsewhere. For more minute data of the latter the reader is referred to the many admirable text-books on pathology.

Gross Pathology in surgical diagnosis, or what can be learned by inspection, palpation, etc., belongs to the clinical consideration and can be dismissed here. The gross consideration of pathologic specimens removed by operation is an important matter, and their proper manipulation immediately after removal not only allows a more critical inspection, but also preserves them for future examination and demonstration. The old method of washing the specimen in running water to remove the blood and then preserving in alcohol, doubtless prevents decomposition, but shrinks and decolorizes it to such an extent that recognition is often impossible. The following procedure is therefore recommended: As soon as possible after the removal of the specimen, the small pieces for histologic examination should be excised and placed in their proper fixative, and then the whole specimen should be immersed in No. 1 Pick's solution without previous washing and before the surfaces have become dry. It is rarely necessary to make incisions, except in very large specimens. Open cavities should be stuffed with absorbent cotton to preserve contour. Closed cavities containing fluid may be aspirated and injected with the preservative. Cross-sections of tumors and organs, especially the kidney, usually show better if made after the specimen is taken out of No. 1 solution.

No. 1 Pick's Solution:
50 grams artificial Carlsbad salts.
1000 c.c. distilled water.
Dissolve, filter, and add
50 c.c. Schering's formalin.

This solution should be freshly prepared for each specimen in ample amount. Specimens look grayish-red and should be kept in the solution from one to five days according to shape and size. They are then placed in 85 per cent alcohol from two to six hours, and the natural color returns.

The specimen is now transferred to No. 2 solution in a large specimen jar, and after remaining there for a number of days it may be placed for permanent preservation in a smaller jar containing the same fluid.

No. 2 Pick's Solution:
300 grams potassium acetate cryst. (c. p.).
1000 c.c. distilled water.
Dissolve, filter, and add
600 c.c. pure glycerin.
For muscular tissue reduce the amount of potassium acetate to 150 grams.

If this method is carefully carried out, it is astonishing how well specimens are preserved in both color and contour.

Pathologic Histology is often most important in surgical diagnosis, and frequently has a direct bearing on the prognosis. The successful outcome of the examination may be largely dependent on the prompt and proper care given the specimen, and for this reason it should be placed in the fixative as soon as possible after its removal from the body.

The usual examinations for diagnosis are as follows:

Small pieces of pseudoplasm excised for diagnosis.

Small pieces excised from diseased tissue which has been removed by operation.

When small pieces of pseudoplasm are excised for diagnosis, the method selected for preparing the specimen for microscopic examination will depend on the time available for this purpose.

If the specimen is removed at the first stage of the operation, and the patient is kept under an anesthetic pending the result of the microscopic examination, or when rapid work is necessary for other reasons, the sections must be made with the freezing microtome. While the technic of frozen sections has been much improved, the pictures which they present are satisfactory only when the structure is a clearly defined one, and continuous use of the method will demonstrate how frequently its results are unsatisfactory or meaningless. It is far preferable to use one of the embedding methods when time allows, as the sections are thinner and the microscopic picture is much more satisfactory. When the surgeon clearly understands the decided advantages of the latter method, the occasions for the use of the freezing microtome will be rare.

Brief Instructions for Making Frozen Sections.—The simple table microtome with a strongly made freezing chamber, the vents of the latter being large enough to prevent clogging and back pressure, and the usual chisel-edged spade-like knife make a satisfactory apparatus. The so-called student's freezing microtome made by Jung, of Heidelberg, as shown in Fig. 48, is inexpensive and far superior to anything in the home market. It can be imported by any one of the supply shops. Compressed carbonic acid gas as a "freezing mixture" is convenient, rapid, certain, and cheap as compared with ether or rhigolene. The steel cylinder containing the liquid CO_2 can be obtained in every city, and is usually loaned without charge to the purchaser of the contents. As shown in the accompanying cut, the cylinder should be inverted and the outlet connected with the freezing chamber by means of heavy rubber pressure tubing wired to the nipples. The valve, which should be on a level with the freezing chamber, must be opened carefully, so as not to burst the rubber tubing. Permanent hospital equipments should not be made with iron pipe for obvious reasons.

A small piece of the fresh specimen, not more than 4 or 5 mm. thick, is placed on the plate of the freezing chamber in a few drops of water and quickly

frozen. After a few seconds, a number of sections are rapidly cut and removed from the knife by immersing it in water. A few of the best sections are placed for two minutes in 4 per cent formalin, for two minutes in 95 per cent alcohol, for two minutes in absolute alcohol, and then transferred to water. They are then stained with methylene-blue (saturated aqueous solution, half strength) for ninety seconds, washed in water, and mounted in glycerin. Thus the slide bearing a presentable section can be under the microscope within twelve minutes after the excision. More rapid methods are available, but the results are usually most unsatisfactory.

Brief Instructions for Making Embedded Sections.—Specimens embedded in celloidin or paraffin may be sectioned on one of the many microtomes in the market, the selection of the instrument depending largely on the amount of work to be done and on the expenditure. For diagnostic purposes, where the paraffin method is used, the student's microtome shown in Fig. 48, the use of the freezing chamber being omitted, is an excellent instrument and can be used for all purposes.

The paraffin method usually leads to the best results, and the following description will be limited to it:*

A small piece of the tissue to be examined (about 1 cm. square, and 3 mm. thick) is placed successively in the following solutions:

6 hours or more......	4 per cent formalin.
6 hours or more......	80 per cent alcohol.
6 hours or more......	95 per cent alcohol.
6 hours or more......	absolute alcohol.
6 hours or more......	chloroform.
6 hours or more......	saturated solution paraffin in chloroform.
1 hour or more......	paraffin bath.

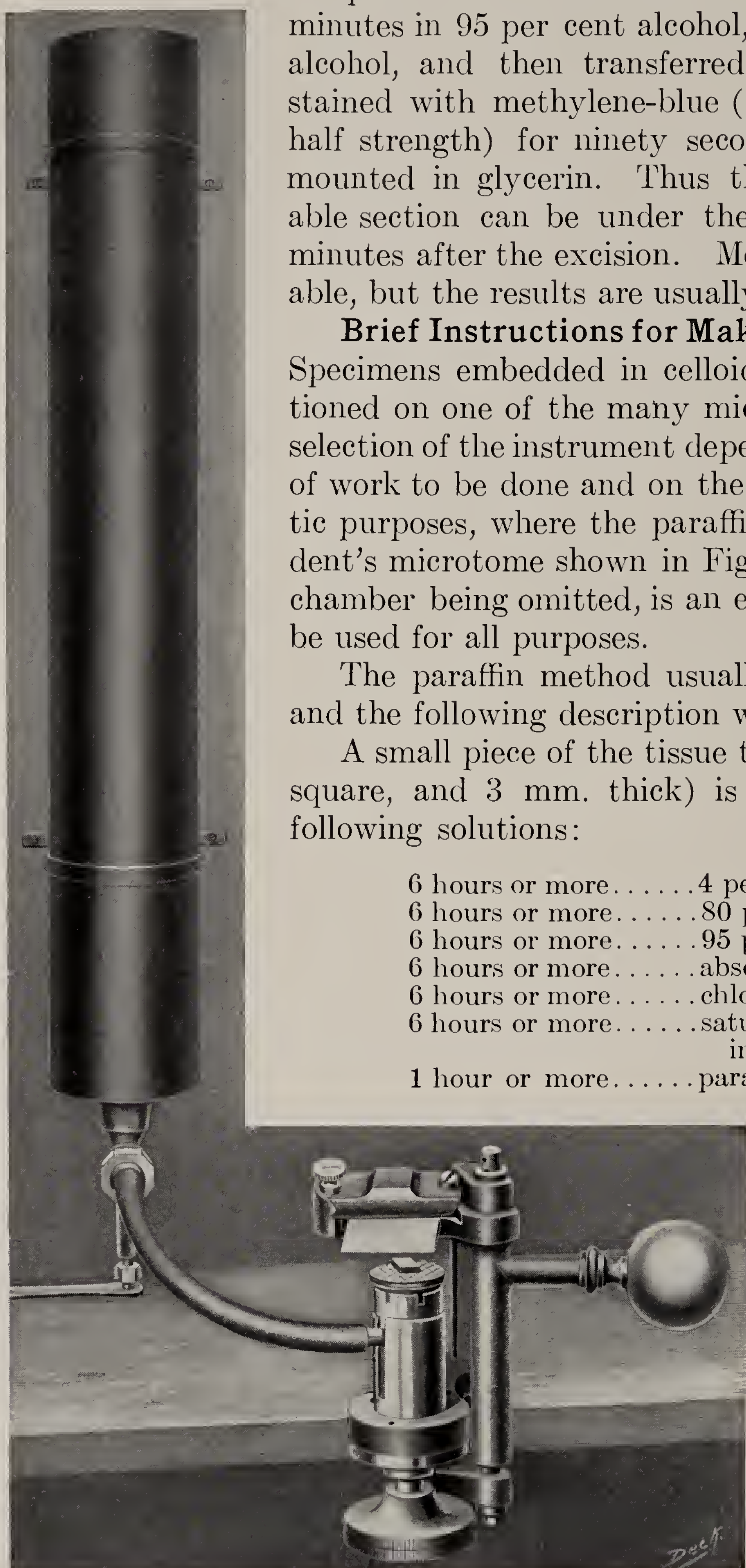


Fig. 48.—Freezing Microtome Made by Jung, of Heidelberg, with Liquid Carbonic Acid Gas Freezing Attachment.

It is then embedded in paraffin, cooled, attached to the object-holder, and cut. The paraffin bath is better replaced by a small incubator kept at a steady temperature by a thermostat, according to the melting-point of the paraffin employed.

The cut sections are placed on the surface of a dish of warm water, in order to remove all

* For a more detailed account of this and other methods, the reader is referred to Mallory and Wright's "Pathological Technique," 3d edition, 1904. W. B. Saunders & Co., Publishers.

wrinkles, and the best ones are then attached to the microscopic slides, which have previously been coated with a glycerin albumen mixture (equal parts of white of egg and glycerin thoroughly beaten and filtered, to which a few drops of carbolic acid may be added as a preservative). The excess is drained, and when the slide is dry, it is placed in the small incubator at about 58° C. for several hours. This will firmly attach the section to the slide. The paraffin is now removed by passing the slide through two or three changes of xylol, followed by absolute alcohol and then by 95 per cent alcohol.

Many simple and elaborate staining methods are now in use to serve particular purposes, but for general histologic work the hematoxylin and eosin method serves most purposes. The section attached to the slide is now placed in water, and then stained from two to thirty minutes in Delafield's hematoxylin. Better results are oftentimes achieved by diluting this stain with water and staining the specimen for a longer period. Delafield's hematoxylin solution is difficult to make, and that made by Grübler can be purchased in any supply shop. After the specimens have been stained they are washed for several hours in frequent changes of water, or in running water for twenty minutes; they are then placed in a 0.2 per cent aqueous solution of eosin for about five minutes. This is followed by two or three changes of 95 per cent alcohol to remove the excess of eosin and for purposes of dehydration. The specimen is now cleared in oleum origani and mounted in Canada balsam. As stated above, the microscopic pictures found in the different pathologic lesions are detailed elsewhere.

BACTERIOLOGIC EXAMINATIONS

These examinations form an important item in laboratory aids in diagnosis, and the heading is placed among these for completeness, but for details the reader is referred to the section on the subject. The bacteriologic investigations of practical value in clinical diagnosis are comparatively simple and should be in general use more than they are. They consist chiefly in direct microscopic examination of secretions or excretions for bacteria, or, if the organisms are not present in sufficient numbers or the morphology is uncertain, in examination of cultures. Direct examinations are quickly made and the advantage of slides instead of cover-glasses is again emphasized. For cultures, a small incubator heated by gas or electricity should be employed. It is inexpensive, occupies but little room, and is easily cared for. If gas is used, a Dunham regulator (Fig. 2) is all that is required, the additional gas-pressure regulator being unnecessary for clinical purposes. All varieties of culture-media may be obtained from any laboratory, or from Parke, Davis & Co. Petri dishes for plate cultures are easily sterilized in the apparatus which every surgeon has in constant use. With the conveniences at home, the surgeon is likely to avail himself of them more frequently than if specimens are sent off to a laboratory. To cite a few pertinent practical examples: Middle-ear secretion containing streptococci is followed by mastoid involvement in over 90 per cent of the cases, whereas staphylococci, pneumococci, and colon bacilli show totally different figures. In other regions of the body a streptococcus infection usually calls for more extensive surgical interference than the presence of other organisms. The value of a culture from the throat to differentiate the bacillus of diphtheria

from streptococcus, and the necessity of a microscopic examination to distinguish a gonorrheal ophthalmia from a benign one, need no more than brief mention.

CHEMIC EXAMINATIONS

The application of chemic analysis as a clinical laboratory diagnostic aid probably owes its delayed advancement to the time demanded by this work and the fact that the medical student was formerly not taught chemic technic to any extent. The great advances in recent years have brought about a necessary change, and a good chemic laboratory in the medical school is the result. Chemic methods of value to the surgeon are mentioned under the head of Specific Examinations.

EXAMINATION OF THE BLOOD

It is within comparatively recent years that hematology has emerged from its theoretic state into a science of practical utility to the clinician, and today it stands as a factor of prime importance to the surgeon in diagnosis as well as in prognosis. The technic of a thorough blood examination has also been simplified to such an extent that it is within the reach of every one. If a blood examination is worth making at all, it is worth making not only well but thoroughly, and the methodic worker is the one who does not overlook pathologic lesions not suspected by the clinical history. For example, the mere leukocyte count of 45,000 has seemed to indicate an inflammatory process in the liver resulting in abscess. The surgeon about to operate and not satisfied with the appearance of his patient has the blood examined by an expert hematologist, with the result that a diagnosis of acute lymphatic leukemia is made, which explains leukocytosis, the patient's prostration, pain, temperature, and area of dullness, and practically excludes the presence of pus.

TECHNIC OF EXAMINATION OF THE BLOOD

A complete routine blood examination is urgently recommended in every instance, but some special work is reserved for special cases requiring the same. This is not the place for a detailed consideration of technic, but the subject will be briefly outlined.*

Routine examination should include the following:
- Estimation of the amount of hemoglobin.
- Count of red corpuscles and leukocytes in 1 c.mm. of blood.
- Differential count of leukocytes and examination of stained specimen.

Exceptional procedures are
- Iodophilic reaction.
- Cryoscopy of the blood.
- Blood cultures.
- A number of these procedures are purposely omitted in the present study, as they belong to internal medicine rather than surgery.

* The reader is referred to Cabot, "Clinical Examination of the Blood," or DaCosta, "Clinical Hematology."

Hemoglobin.—The estimation of the amount of coloring-matter is, from a scientific point of view, the least satisfactory procedure in present day hematology, but it must be employed in the absence of better clinical means. Of the numerous methods in use, the Dare hemoglobinometer and the Tallqvist scale are worthy of mention.

The **Dare hemoglobinometer,** as shown in the accompanying illustration, is the best instrument in use. The undiluted blood is drawn by capillary

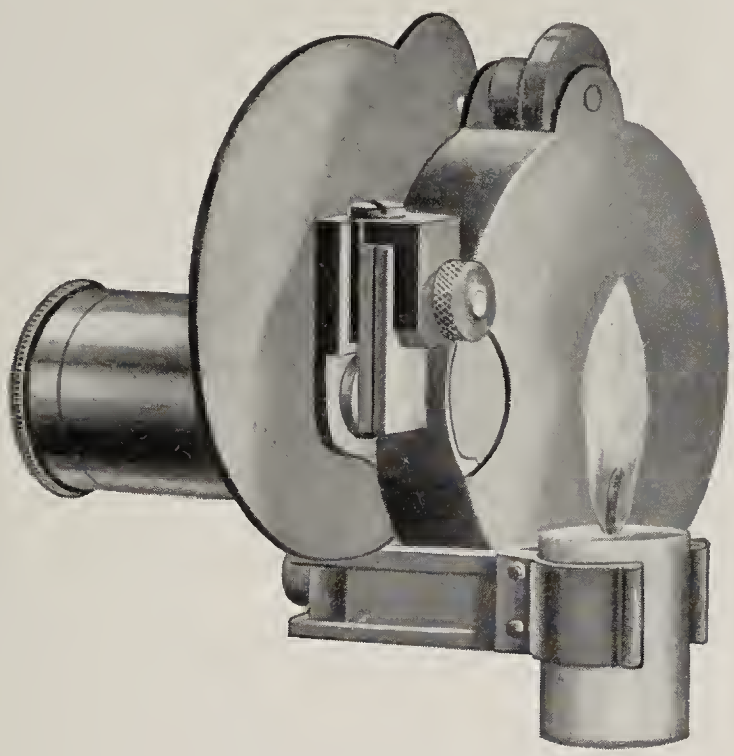


FIG. 49.—THE DARE HEMOGLOBINOMETER.

attraction between two glass plates which form a chamber of measured thickness. The color is then compared with the color plate, the two are matched, and the result read from a conveniently placed scale.

The **Tallqvist scale** is not nearly so accurate as the above method, but is far preferable to no determination of hemoglobin at all. It consists of a series of standard tints representing a scale from 10 to 100 by tenths, and is used in

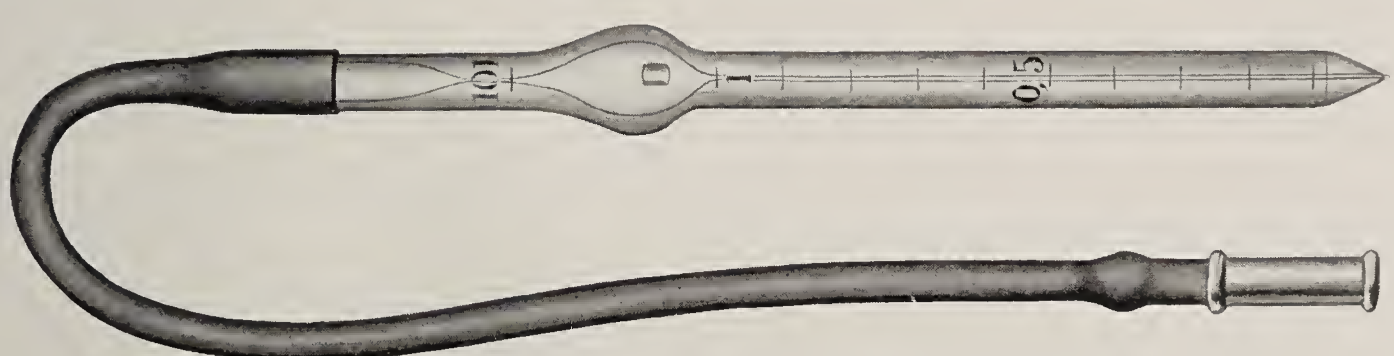


FIG. 50.—THOMA-ZEISS HEMOCYTOMETER FOR DILUTIONS OF 1 : 100 AND 1 : 200.

daylight. A large drop of blood is received on a piece of white filter-paper, strips of which accompany the color scale, and is then compared with the scale.

In the estimation of hemoglobin the arbitrary normal is placed at 100 per cent, but our city dwellers rarely show this figure. The Fleischl apparatus, of which there are many in use, shows the lowest readings.

Count of Red Corpuscles and Leukocytes.—The fresh blood is diluted in proportion of 1:100 or 1:200, the corpuscles in a given cubic space are counted under the microscope, and thus the number of corpuscles in

1 c.mm. is computed. For the purpose of dilution, the Thoma pipet made by Zeiss, as shown in the illustration, is the best one. The blood is drawn to the figure 1, and after the excess is carefully removed from the tip of the pipet, it is filled to the mark 101 with Toisson's solution, the resulting dilution being 1 : 100. Toisson's solution is made as follows:

Methyl violet 5 B	0.012
Sodium chlorid	0.5
Sodium sulfate	4.0
Glycerin, pure	15.0
Distilled water	80.0

After the dilution in the pipet is thoroughly mixed by means of the contained small glass ball, a number of drops are blown out and a small one is placed in the center of an absolutely clean Thoma-Zeiss containing chamber and quickly covered with the cover-glass of the apparatus, the presence of Newton's rings indicating proper contact. The counting chamber having the

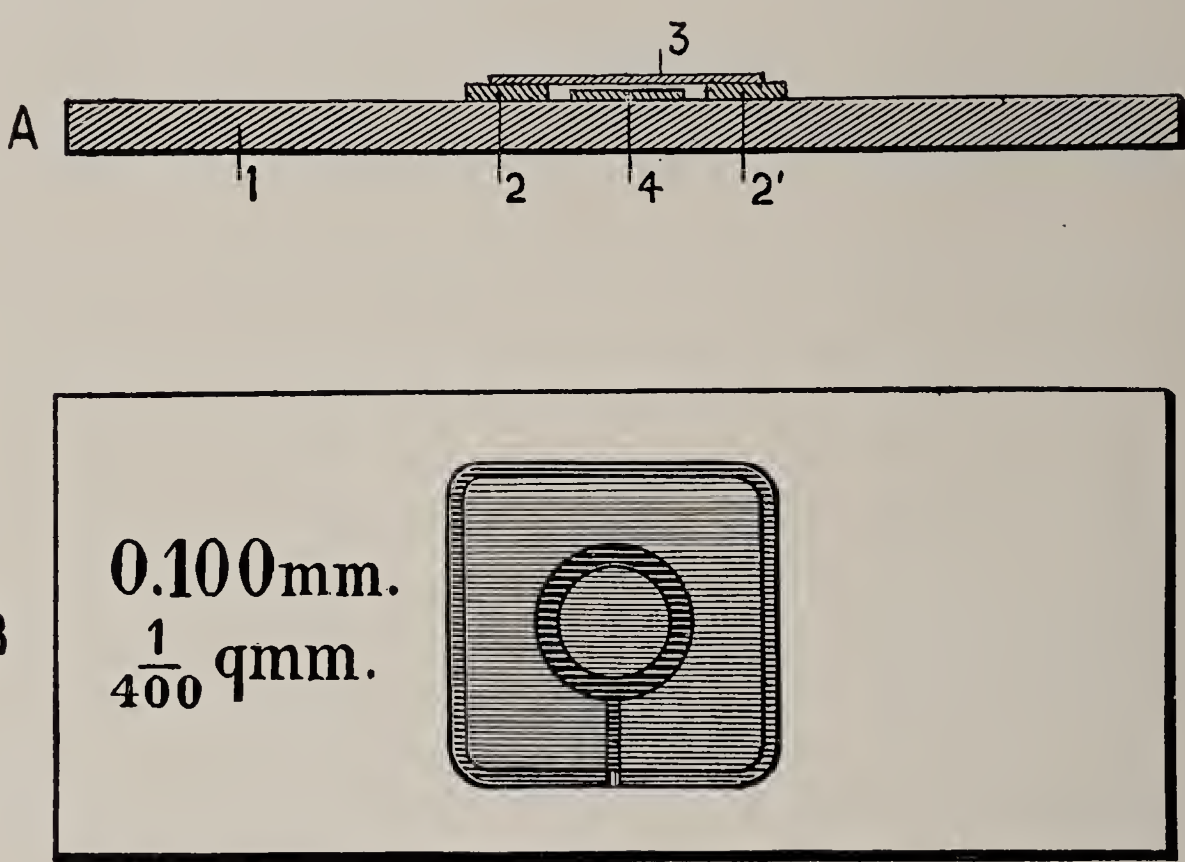


FIG. 51.—THOMA-ZEISS COUNTING CHAMBER.
A, Cross-section. B, Plan view. 1, Glass slide; 2, 2', tinted glass for support of cover; 3, cover-glass; 4, circular ruled glass disk. Actual chamber for blood is between 3 and 4.

Elzholz ruling, as shown in Fig. 52, is preferable to that having the Thoma ruling, as both the red corpuscles and the leukocytes can be counted in the same specimen. A good plan is to count the red corpuscles in the small squares marked with dots in the illustration, and all the leukocytes in the entire ruled surface. The counting chamber is then cleaned and the procedure repeated. In this way the red corpuscles in 120 small squares have been counted (for example, 1140), and the number in 1 c.mm. can be figured as follows:

1140 × (dilution) 100 × (cubic space of square) 4000 ÷ (squares counted) 120 = 3,800,000 red corpuscles in 1 c.mm. of blood.

The normal figures usually quoted are, males 5,000,000, females about 4,500,000, but perfectly healthy persons deviate from this rule. The leukocytes in the

equivalent of 7200 small squares have been counted (for example, 144), and the number in 1 c.mm. can be estimated as follows:

$$144 \times 100 \times 4000 \div 7200 = 8000 \text{ leukocytes in 1 c.mm. of blood.}$$

A table of 5000 blood specimens shows the following figures for healthy adults: Leukocytes in 1 c.mm. of blood from 5200 to 9600, the average being 6700.

Differential Count of Leukocytes and Microscopic Examination of Stained Specimens..—This procedure is of the greatest importance in the diagnostic significance of hematology, and it is the feature which is most frequently neglected on account of its supposed difficulty and expenditure of time. As a matter of fact, the new staining methods and some experience make it the least tedious of the different steps in a routine blood examination.

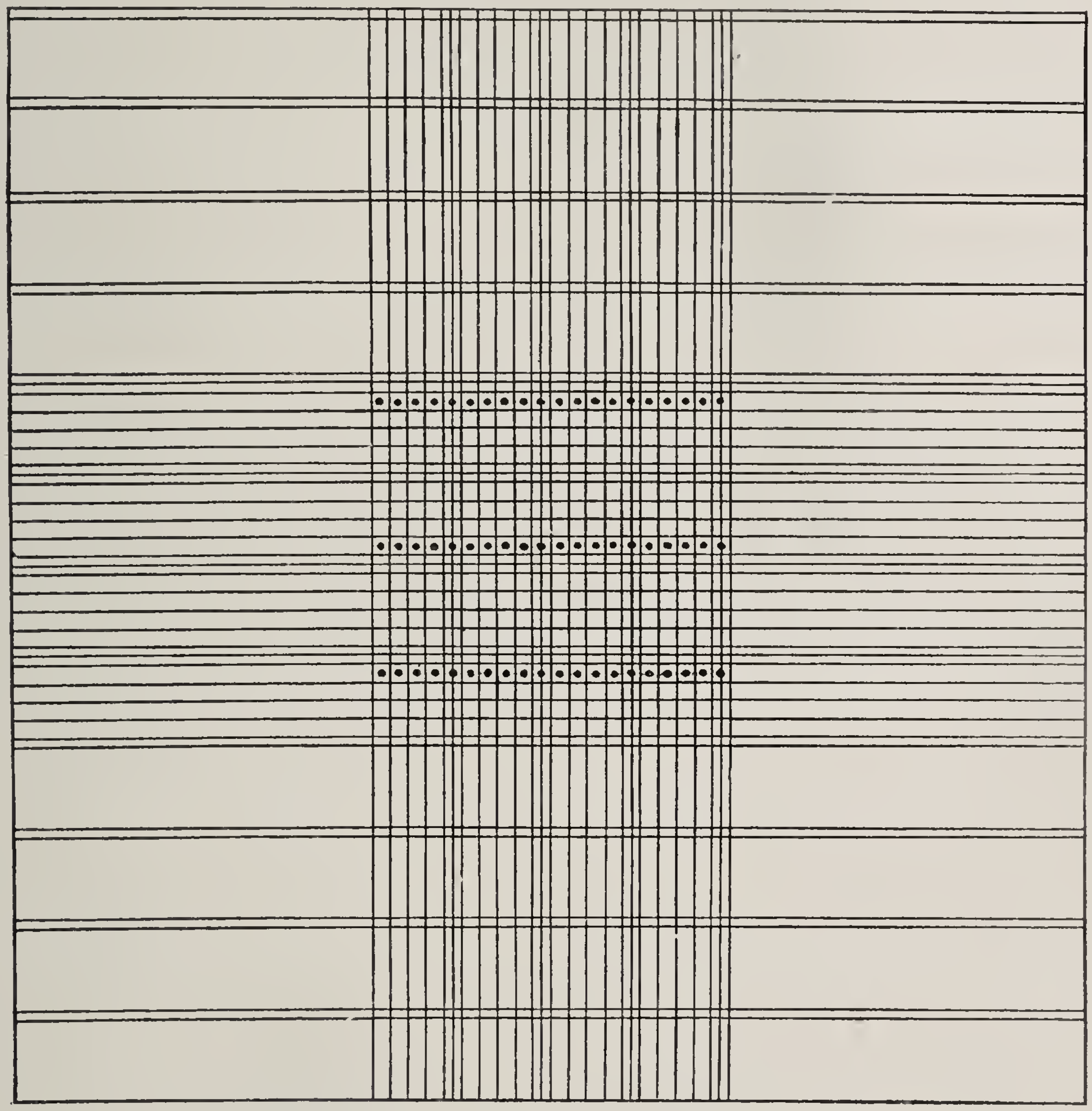


Fig. 52.—Elzholz Ruling of Counting Chamber. (Magnified 30 times.) Red corpuscles are counted in the squares marked with dots. Leukocytes are counted in entire ruled space.

The smears are best made on slides instead of cover-glasses, and a little practice results in thin and even specimens in which the corpuscles have not been injured by pressure. For the purpose of fixing and staining, these are placed for several minutes in a covered vessel containing Wright's stain, then removed and a drop or two of water added to dilute the stain adhering to the specimen. This is allowed to remain two or three minutes, and the specimen is then washed in water until it has a yellowish-pink color. The process of decolorization and differentiation is the objection to Wright's stain, but this can be avoided by making a mixture of Jenner's stain, 2 parts, and Wright's stain, 1 part. With this solution specimens are stained for

several minutes, quickly washed in water, and dried with filter-paper. Microscopic examination of the slides shows the character of the red corpuscles, of nucleated ones if any are present, plasmodia, etc., and the differential count is obtained by noting the relative number of the different varieties of leukocytes, successively encountered by moving the slide with a mechanical stage; an actual count of 500 is usually sufficient.

The table of 5000 examinations mentioned above shows a normal differential count of leukocytes to be as follows:

Leukocytes.	Percentages.			Actual Number in 1 c.mm. Based on Average Leukocyte Count of 6700.
	Low.	High.	Average.	
Small Lymphocytes	24.0	35.0	28.0	1,876
Large Lymphocytes	3.0	10.0	7.5	502
Polynuclear Neutrophiles	59.0	68.0	62.0	4,154
Eosinophiles	0.2	4.0	1.0	67
Basophiles	None	0.4	0.2	7

Iodophilic Reaction. — In a number of pathologic conditions the protoplasm of the polynuclear cells has an affinity for iodin, and when stained

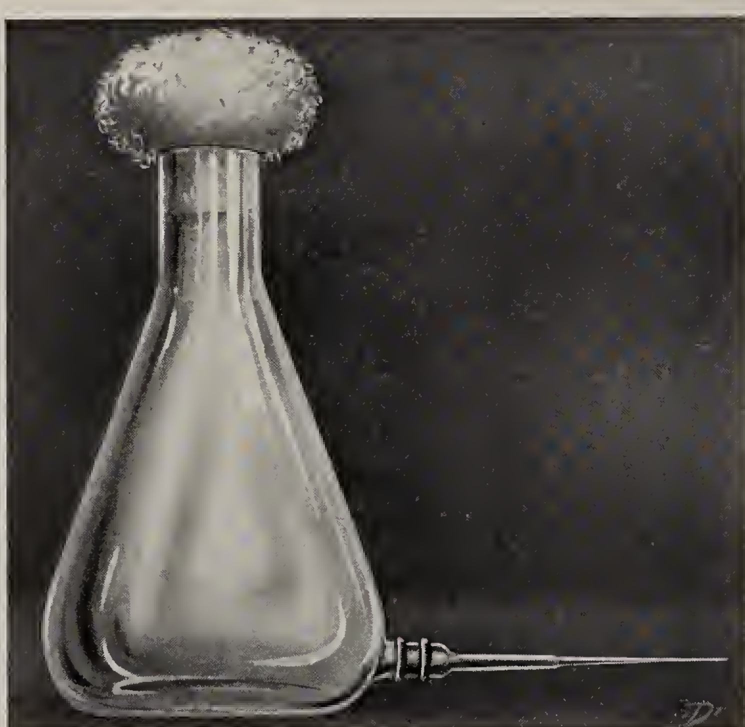


Fig. 53.—Thatcher "Mosquito."

with the reagent, shows an intense brown coloring with granules of even darker color, while the specimen without this affinity shows a slight yellow color only. The value of the reaction will be considered later.

The test is applied as follows: A drop of the reagent is placed on the dry and unstained blood slide and a cover-glass applied. The specimen is examined under the microscope after a lapse of about three minutes. The reagent is easily made fresh for each examination by mixing 1 part of Lugol's solution with 2 parts of pure glycerin.

Cryoscopy of the Blood.—The value of this procedure, as well as the technic of the same, will be detailed under the head of Urine Analysis.

Blood-cultures.—The direct search for bacteria in blood-smears is very rarely successful, and may be disregarded for practical purposes, but their

demonstration by culture from the blood is of great importance, especially in the matter of prognosis. The presence of streptococci makes the prognosis exceedingly grave, while the presence of staphylococci is much more frequently followed by recovery. Scrupulous care to prevent contamination of the culture is imperative, and many misleading results may be ascribed to imperfect asepsis. The bend of the elbow must be rendered thoroughly aseptic in the most stringent manner of the surgeon ; compression of the arm will distend the superficial veins and render them more prominent. The hypodermic needle of the previously sterilized Thatcher "mosquito," shown in Fig. 53, is now thrust into the vessel and the blood immediately flows into the receptacle. A previous small incision reduces to a minimum the liability to pick up organisms from the skin. One c.c. of blood is now added to 100 c.c. of broth or other fluid culture-medium in a suitable flask, mixed, and placed in the incubator. Three such flasks are usually prepared. Should a growth develop, the exact character of the organism is determined by transplantation and microscopic examination, as detailed in the section on Bacteriology. The original use of fluid culture-media will be found much more satisfactory than the use of solid ones, though plates made at once often give good service.

CLINICAL SIGNIFICANCE OF BLOOD-CHANGES

In the following enumeration the features of interest to the surgeon are given special attention, and topics belonging to general medicine are considered only if they are of value in surgical diagnosis and prognosis. Two tables, however, are appended briefly enumerating the changes noted in blood diseases.

Anemia and its Influence on Surgical Prognosis.—In view of the present state of hematology the arbitrary rule largely held, that no surgical procedure is to be undertaken when the percentage of hemoglobin is below 30, is in need of amendment. The determination of the amount of hemoglobin in those specimens poor in coloring-matter is very crude at best, and an opinion concerning the prognosis in any operation in a case of severe anemia is much better if based on the complete blood-picture, than if the necessarily crude estimate of the amount of hemoglobin alone is considered. The chlorotic girl with 30 per cent hemoglobin, $4\frac{1}{2}$ million red corpuscles, a normal leukocyte count, and a normal differential count, is certainly in a much better condition to withstand an imperative operation than one having secondary anemia with 50 per cent hemoglobin, but only 2 million red corpuscles, a marked leukopenia, and a high relative lymphocytosis.

Leukocytosis and Differential Count in Inflammation.—This is to the surgeon the most important feature in blood examination, and consequently deserves consideration at length. For a long time the number of leukocytes in a given quantity of blood has been looked to as a guide for the existence and severity of the inflammatory process, with a view of determining the degree of leukocytosis which shows inflammation without exudate or with serous noninfectious exudate, the degree with which a purulent exudate may be expected, and, finally, that which indicates a degree of systemic poisoning that would make any operative interference a hazardous procedure. It was soon found that arbitrary limits could not be established, and that the presence of leukocytosis was not invariable in suppurative conditions, particularly in the fulminating cases. This latter feature has been the greatest obstacle to progress, as it has discouraged observation.

SCHEMATIC TABLE OF DIFFERENTIAL DIAGNOSIS IN EXAMINATIONS OF BLOOD.

Disease.	Hemoglobin.	Red Corpuscles.		Leukocytes.		Remarks.
		Number.	Form.	Number.	Varieties.	
Simple anemia or chlorosis, slight	50 to 70 %.	Normal.	Normal.	Normal.	Normal.	*Characteristics:* Diminution in hemoglobin much greater than in red corpuscles. (Low color index.)
Simple anemia or chlorosis, severe	25 to 50 %.	Diminished to $3\frac{1}{2}$ million.	Small and pale. Poikilocytes. Nucleated cells rare.	Leukopenia.	Usually relative lymphocytosis.	
Secondary anemia.	Diminution in hemoglobin and in red corpuscles usually approximately equal.		Changes according to severity from none to pictures closely simulating pernicious anemia.	Number of leukocytes and differential count depend on the condition to which the anemia is secondary.		*Characteristics:* Equal diminution in hemoglobin and red corpuscles. If extreme, the normoblasts outnumber megaloblasts.
Pernicious anemia.	Diminished as low as 15 %.	Much diminished as low as $\frac{1}{2}$ million.	Most irregular. Megaloblasts should outnumber normoblasts.	Leukopenia.	Lymphocytosis, occasionally few myelocytes.	*Characteristics:* Diminution in red cells much greater than in hemoglobin. (High color index.)
Acute lymphatic leukemia.	Rapid diminution. Type as in secondary anemia.		Some poikilocytosis. Nucleated cells rare.	150,000 or lower to 350,000.	Increase is chiefly in number of large lymphocytes.	*Characteristics:* Rapid secondary anemia. High leukocyte count. Increase chiefly in number of large lymphocytes.
Chronic lymphatic leukemia.	Gradual diminution. Type as in chlorosis.		Some poikilocytosis. Nucleated cells rare.	100,000 or lower to 300,000.	Increase is chiefly in number of small lymphocytes.	*Characteristics:* Anemia of chlorotic type. High leukocyte count. Increase chiefly in number of small lymphocytes.
Myeloid leukemia.	Rather rapid diminution. Type as in chlorosis.		Poikilocytes. Many nucleated cells.	100,000 to 600,000 higher than in lymphatic leukemia.	Many myelocytes. Numerous basophilic cells.	*Characteristics:* Anemia of chlorotic type. Leukocyte count higher than in lymphatic leukemia. Presence of myelocytes.
Hodgkin's disease.	Normal or diminished.	Normal or diminished.	Normal or as in secondary anemia.	Normal or slight leukocytosis.	Normal or slight lymphocytosis.	*Characteristics:* Negative evidence as compared with leukemia.

Note.—Exceptional cases may, of course, deviate from the above rules.

APPROXIMATE DIFFERENTIAL COUNT OF LEUKOCYTES.

Leukocytes.	Normal Blood.	Chlorosis.	Secondary Anemia.	Pernicious Anemia.	Acute Lymphatic Leukemia.	Chronic Lymphatic Leukemia.	Myeloid Leukemia.
Small lymphocytes	28 %	35 %	38 %	42 %	4 %	88 %	8 %
Large lymphocytes	7 %	6 %	6 %	4 %	90 %	5 %	3 %
Polynuclear neutrophiles	62 %	58 %	55 %	50 %	4 %	7 %	30 %
Eosinophiles	1 %	1 %	1 %	3 %	0.5 %	0.2 %	6 %
Basophiles	0.2 %	0.2 %	0.2 %	0.2 %	...	...	0.2 %
Myelocytes	...	...	...	1 %	2 %	...	45 %
Eosinophilic myelocytes	...	...	...	...	...	...	8 %

Leukocytosis is largely dependent on body resistance toward infection, and therefore the degree of increase can be no guide to the intensity of the pathologic process. Good resistance will produce pronounced leukocytosis even in slight infections, and poor resistance but little leukocytosis in slight infections, and possibly none at all in grave infections. No adequate clinical method exists by which this body resistance can be determined with sufficient accuracy to apply it as a factor in the leukocyte count, and this is the key to the disappointments encountered by the surgeon in utilizing these counts in diagnosis. It is also the reason why arbitrary leukocyte count standards indicating definite degrees of lesion cannot be fixed. At first a leukocytosis of 10,000 was looked upon as indicating the presence of pus, while more recently it has been stated that at least 35,000 leukocytes must be present before pus may be suspected, though pus is often present with much lower counts.

It has been found, however, that the quantitative relation or differential count of leukocytes offers a better guide to the status of an inflammatory process than the mere presence of leukocytosis, with the additional advantage that it is not particularly influenced by body resistance. Furthermore the leukocytosis present with a given differential count is a direct indicator of body resistance. The particular point in question is the relative percentage of polynuclear neutrophiles. This percentage varies somewhat in health, as shown in the above table. Moderate fluctuations in the anemia accompanying most pathologic states as well as in the different stages of body resistance are also observed. These fluctuations, however, are within fairly narrow limits. A careful analysis of 1415 blood examinations in surgical cases shows three distinct blood pictures in inflammatory lesions, grouped as follows:

1.—A relative percentage of polynuclear cells below 70, *with an inflammatory leukocytosis of any degree*, excludes the presence of gangrene or pus, at the time the blood examination is made, and usually indicates good body resistance toward infection. Of the large number of instances, but two will be briefly mentioned, which will illustrate the point.

No. 12,971.—A robust young woman. Red cells 4,900,000. Hemoglobin 82 per cent. Serous otitis media. Owing to extreme pain, condition of pulse, etc., acute mastoid disease suspected. Leukocyte count 28,400. Polynuclear cells 59.7 per cent. Clinical picture and leukocytosis would have

indicated immediate operation, but the normal polynuclear percentage led the aurist to wait, and a prompt recovery without purulent exudate made operation unnecessary.

No. 13,610.—A boy, convalescing from severe attack of an acute infectious disease, presented a clinical picture of acute appendicitis and a leukocytosis of 25,100. While surgical interference seemed urgently indicated, the general condition made it a risk not to be incurred unless imperative. The polynuclear percentage of 63.5 induced the attending physician to wait, and while he spent anxious days in which the clinical signs and blood picture remained stationary, resolution without pus or gangrene resulted, and the child was saved an operation at a time when he was in very poor condition to stand it.

2.—An increased relative percentage of polynuclear cells, even with little or no inflammatory leukocytosis, is still an absolute indication of the inflammatory process, *and the percentage is a direct guide to the severity of the infection.* As above stated, in all the cases no pus or gangrene was ever observed with a polynuclear percentage below 70. In children, in whom the polynuclear percentage is normally lower than in adults, pus or gangrene has been observed with the percentage as low as 73. In adults a purulent exudate or a gangrenous process is decidedly uncommon with less than 80 per cent of polynuclear cells, and the probability of their presence increases with the percentage. Eighty-five per cent or over of polynuclear cells was never seen without a purulent exudate or gangrenous process irrespective of the leukocyte count. Ninety per cent of polynuclear cells has always indicated a very severe degree of cachexia, if the term may be used, and while one specimen of 95.2 per cent was seen where recovery followed operation, all other cases in which the percentage was over 94.5 resulted fatally. It is not wise to establish narrow arbitrary limits, nor should this be attempted, but the above figures are based on the 1400 surgical cases studied in this way.

This second type of increased polynuclear percentage is the most interesting one, as it particularly demonstrates the value of the advocated procedure in cases that are usually in urgent need of operation on account of poor body resistance. The few cited cases will illustrate:

No. 11,509.—A young woman in apparently good condition. Red cells 4,208,000. Hemoglobin 72 per cent. Severe pelvic cellulitis from streptococcus infection, and somewhat vague manifestations of an abscess, with a leukocyte count of 7200. Her serious condition could be explained clinically by the intensity of the inflammatory process, but the polynuclear percentage of 87 indicated the necessity for immediate operation, which revealed a large collection of pus. The operation was followed by recovery.

No. 12,331.—A rather feeble elderly lady. Red cells 4,400,000. Hemoglobin 70 per cent with typic clinical evidences of appendicitis. The attending physician and the consulting surgeon advocated operation, but the consulting physician advised waiting. Leukocytes 13,200. Polynuclear cells 82.4 per cent. Owing to the latter feature, the surgeon insisted on operating, and found a perforated gangrenous appendix and spreading general peritonitis.

No. 13,702.—A young man apparently in good condition. Red cells 4,820,000. Hemoglobin 80 per cent; patient convalescing from an operation for purulent otitis media and mastoid involvement, began to have evidences of meningeal irritation, with but slight clinical manifestations of acute inflam-

Typic Blood Pictures in the Following Conditions:

A. Normal blood. 1. Small lymphocyte. 2. Large lymphocyte. 3. Polynuclear neutrophile. 4. Eosinophile. 5 Basophile. Red corpuscles all normal.

B. Abnormal cellular elements found in blood. 1. Poikilocytes, microcytes and macrocytes. 2. Normoblasts. 3. Megaloblasts. 4. Myelocytes. 5. Eosinophilic myelocytes.

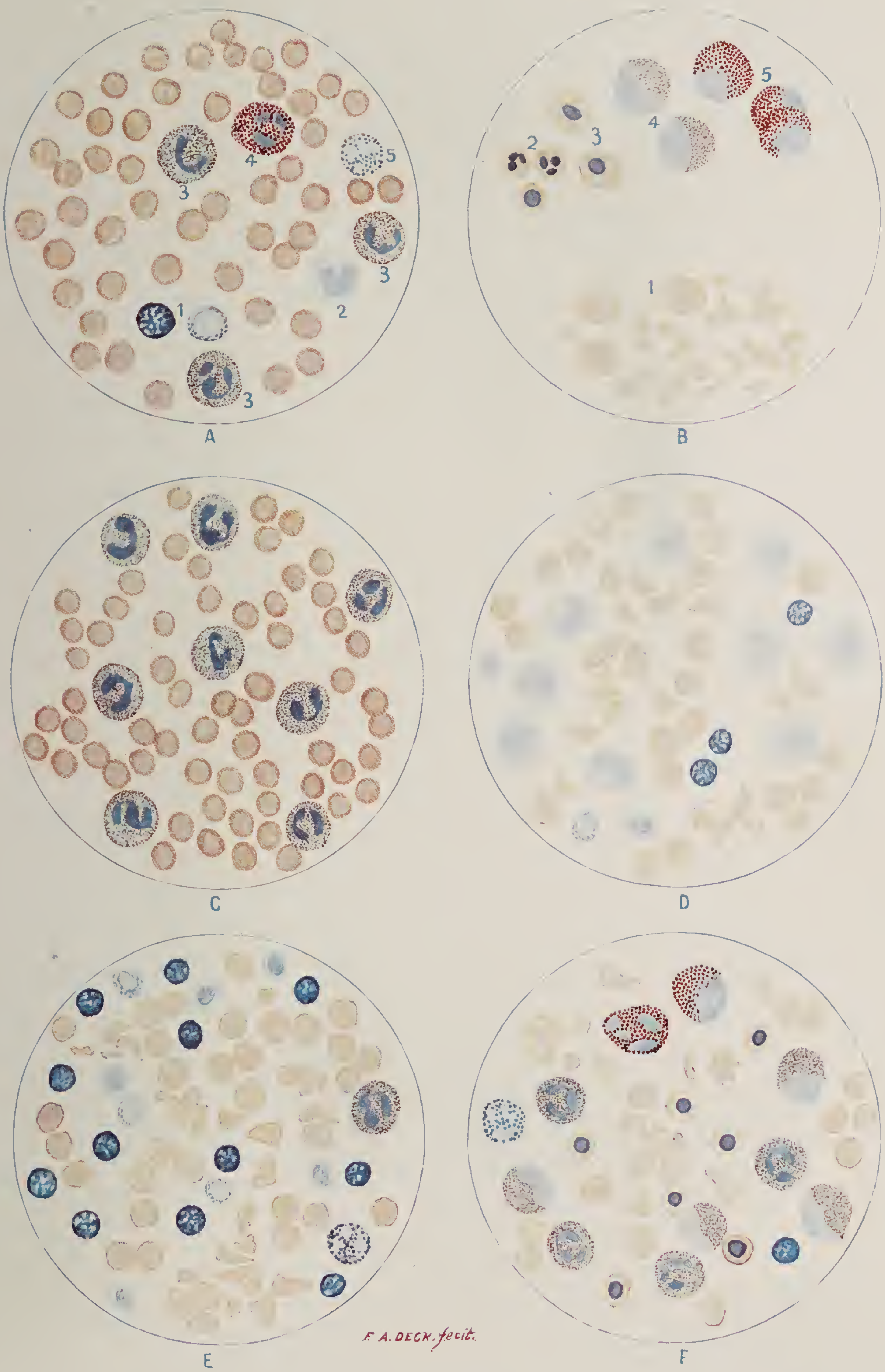
C. Inflammatory leukocytosis with increase in polynuclear cells. Note large number of polynuclear neutrophiles.

D. Acute lymphatic leukemia. Note predominance of large lymphocytes which stain rather poorly.

E. Chronic lymphatic leukemia. Note predominance of small lymphocytes.

F. Myelogenous leukemia. Note myelocytes and many nucleated red cells.

PLATE III



mation. Leukocyte count 11,900. Polynuclear cells 82.3 per cent. Immediate operation revealed large abscess, and patient subsequently died of meningitis.

3.—An increased relative percentage of polynuclear cells with a decided inflammatory leukocytosis. Most of the cases of inflammatory lesions, with or without purulent exudate, meet the specifications of this class. Here, as in the last series, the percentage of polynuclear cells was found to be an accurate guide to the status of the inflammatory lesion. The figures quoted above apply here as well.

The body resistance toward the infection is a most important point, and the clinical manifestations are usually a good guide, but by no means an invariable one. Good resistance, marked leukocytosis; poor resistance, little or no leukocytosis, is the old rule. As stated above, the leukocytosis with a given percentage of polynuclear cells is one of the best indicators of this body resistance, when we accept the theory that the polynuclear percentage is the index of the degree of the inflammatory lesion.

For example, a patient has an inflammatory lesion without purulent exudate, and a polynuclear percentage of 75. If his leukocyte count is 25,000, the body resistance is much better than if the count is 10,000. Another case has an acute inflammation with abscess, and a polynuclear percentage of 84. If the leukocyte count is 30,000 the body resistance is much better than if the count is 15,000. The severely toxic patient with 92 per cent polynuclear cells is combating his disease with greater energy and success if he has 40,000 leukocytes in 1 c.mm. than if they are only 20,000; and should the leukocyte count be 7000, this is a clear indication of an absence of all systemic effort to overcome the infection.

The following must be kept in mind: *Few rules ever existed that have no exceptions. Inflammatory lesions belonging to the domain of general medicine, notably pneumonia, and severely toxic conditions such as scarlet fever show blood pictures which closely simulate those of surgical suppurative lesions.*

Iodophilia.—This reaction, the technic for obtaining which has been detailed, is noted in the blood in all inflammatory lesions, and its presence as well as its intensity has been used as a guide to the character and severity of the inflammatory process. Personal experience teaches its inferiority as a guide to the degree and type of the inflammatory process as compared with the method detailed above. A distinct iodophilic reaction is always obtained in a pronounced leukocytosis, and may erroneously indicate a suppurative process, which error would be most likely in the class of cases enumerated in Group 1.

Tuberculosis.—Lesions due to pure tuberculous infections, necrotic or otherwise, do not occasion a leukocytosis or change in the differential count, the blood usually presenting a picture of secondary anemia. If the tuberculous lesions are the seat of a mixed infection, the leukocytosis and differential count behave as they would if the additional microorganisms were present alone. It is often observed that tuberculous meningitis and tuberculous peritonitis seen in children present a leukocytosis and polynuclear increase, but the presence of a mixed infection to account for this is by no means excluded, though not invariably found on examination.

Malignant Disease.—It was hoped that the examination of the blood would present characteristics of pathognomonic value in the diagnosis of malignant disease, but up to the present this hope has not been realized.

Carcinoma is usually accompanied by the evidences of a rather pronounced secondary anemia, and oftentimes on differential count, shows a leukocytosis and an increase in the percentage of polynuclear cells, which in the absence of a febrile movement is supposed to be of value in the diagnosis. When these features are found, they may be significant, but many cases of carcinoma fail to show them. It is believed that the leukocytosis and polynuclear increase observed in these cases are due to a secondary infection, and thus may be a guide to the extent of the accompanying inflammation, but that they are no indication of the nature or severity of the primary lesion.

Sarcoma is usually accompanied by a secondary anemia also noted in carcinoma, and more frequently, but not invariably, shows a decided leukocytosis and polynuclear increase. The value and significance of these changes are believed to be the same as in cancer.

In the differential diagnosis of **gastric ulcer** and **gastric cancer** the blood examination usually lends no conclusive evidence, but it is noteworthy that in ulcer a leukocytosis is rare, the secondary anemia seldom pronounced, and a relative lymphocytosis common. In the differential diagnosis of obscure malignant disease and pernicious anemia, the following features are worthy of note, viz.:

Pernicious Anemia.	Carcinoma.
Loss of red corpuscles greater than that of hemoglobin (low color index).	Loss of hemoglobin and red cells approximately equal, as in all secondary anemia.
In number of nucleated red cells, megaloblasts always predominate.	If nucleated red cells are present, they are only normoblasts.
Leukopenia common and differential count shows relative lymphocytosis.	Leukocytosis common, and if present shows an increase in polynuclear percentage.

Scurvy and allied conditions and pronounced jaundice are frequently associated with a marked reduction in the coagulability of the blood, which feature is of importance in contemplated surgical procedure. Determining the coagulation period is a rather tedious matter, and but little work in this direction has yet been done. The coagulometer of Wright is the best apparatus devised for the purpose.

Acute Lymphatic Leukemia.—The general blood-picture in this disease has been outlined in the tables on preceding pages. In these cases a sudden increase in lymphatic tissue, interorganic hemorrhages, or both, with temperature and other clinical evidences, often closely simulate acute inflammatory lesions, and therefore are brought to the attention of the surgeon. Omission of a diagnosis by proper examination of the blood may lead to operative interference for a supposed abscess, which can but hasten the invariably fatal outcome of this disease. While the leukocytosis encountered is usually much higher than that of inflammation, this may not be so, and a differential count is an absolute necessity in establishing the diagnosis.

Chronic Myelogenous and Chronic Lymphatic Leukemia.—The general blood-picture in these conditions has been detailed in the tables. The only interest that they have for the surgeon is in the diagnosis of enlargements, glandular and otherwise, encountered in the body. Concerning the significance

of these diseases in surgical prognosis but little has been written, probably because operations are rarely undertaken. Personal observation of the writer is limited to parturition in two cases of the myelogenous form. Both had normal confinements, one a brisk but short postpartum hemorrhage. A moderate febrile movement was noted in both during the postpartum period of several weeks, without sepsis or change in the blood-picture. The parturition did not seem to alter the general condition. As the diagnosis in both was not made until the time of parturition, no data are at hand as to the duration of the disease or the influence of the pregnancy on it. Both children were well nourished and perfectly normal.

Hodgkin's disease or pseudoleukemia is of interest here on account of the differential diagnosis from lymphatic leukemia; the details of the blood-pictures have been enumerated. The differential diagnosis of pseudoleukemia and lymphosarcoma is often difficult, but the latter is likely to show a greater degree of secondary anemia, less relative lymphocytosis, and frequently a leukocytosis with polynuclear increase.

Blood-pressure.—The determination of the blood-pressure by means of the Riva-Rocci or similar apparatus has been found to be of considerable value, but it is a clinical rather than a laboratory procedure.

URINE ANALYSIS

In consequence of the increased value of this procedure during late years, its technic has undergone change and improvement. At one time the clinician believed that, when he had found the specific gravity, had tested the urine for albumin and sugar, and had made a hasty microscopic examination of the sediment, he had exhausted all practical information to be obtained from this complex fluid. Today an examination of this kind is not considered sufficiently exhaustive to meet the exacting demands of the expert diagnostician.

The general idea formerly held, that the presence of albumin indicates a nephritis, and that the finding of granular casts means the presence of chronic renal disease, must be abandoned. Albumin may be found in the urine without a true nephritis, and, on the other hand, a nephritis does not necessarily mean that albumin is constantly present. The same applies to the presence of casts; many granular casts may occur in convalescing acute nephritis and perfect recovery result, and, on the other hand, cases of advanced but quiescent chronic nephritis may show no casts for long or short periods.

In the following consideration of the subject the clinical significance of the latter to the surgeon is kept constantly in mind; the portion belonging to general medicine is alluded to when it seems necessary, and the technic is elaborated only where experience teaches its advisability.

The cardinal points in urine analysis are the selection of a proper specimen and a methodic routine analysis. In most instances a twenty-four hour specimen should be insisted on, as it presents many significant points not learned in any other way, and careful instructions to begin and end the period of twenty-four hours with an empty bladder and to prevent loss at stool are usually necessary. If methodic routine analysis is not constant, important unsuspected conditions may be overlooked; for example, owing to the omission

of a test for glucose because the specific gravity created no suspicion in this direction, a case of postoperative diabetic coma may be a disagreeable surprise.

Before considering the typic and atypic pictures presented by the urine in the more important surgical diseases, there are a few **general considerations** which merit comment.

THE QUANTITY OF URINE

The normal quantity of urine is, generally speaking, from 1000 c.c. to 1200 c.c., though persons in perfect health regularly pass smaller or larger amounts, owing to the fact that they habitually take smaller or larger amounts of fluid during the day.

Polyuria, or an increased daily amount of urine, may be due to physiologic or pathologic causes. Aside from the common pathologic causes, diabetes mellitus, so-called diabetes insipidus, neurotic diseases, that following acute febrile diseases, chronic nephritis of atrophic type, and other conditions belonging to general medicine, the causes which particularly interest the surgeon in diagnosis are (1) the polyuria due to diuretics and the ordered intake of much fluid; (2) pyelitis from any cause; (3) a previously removed kidney; (4) compensatory polyuria due to occlusion of one ureter; (5) the polyuria seen with myelomas of bone and an excretion of Bence-Jones albumin. Oliguria, or the diminished excretion of urine, is noted in febrile diseases, cardiac insufficiency, acute nephritis, and in many other conditions which belong to the domain of general medicine. The causes which interest the surgeon are (1) the post-operative oliguria, especially if hemorrhage has been profuse; (2) the oliguria noted immediately after the removal of one kidney, which is soon followed by a polyuria; (3) the fact that a unilateral painful lesion in or about the kidney, without obstruction to the flow of urine, may produce a decided reflex oliguria. This should be noted particularly. Anuria, or the absence of renal excretion, is an exaggerated form of oliguria, and is due to the same causes.

ALBUMIN

In testing for albumin the methods selected should be such that not only serum-albumin but also nucleo-albumin, albumose, and Bence-Jones albumin are revealed at the same time. Absolute accuracy in this regard calls for the use of many tests not feasible as a surgeon's routine procedure, but for general clinical routine work the use of two tests is advised—the heat and nitric acid test and the nitric-magnesium test.

The **heat and nitric acid test** should be made as follows: A test-tube three-quarters full of perfectly clear filtered urine is inclined at an angle of 45 degrees, and the upper inch heated by means of a Bunsen burner or an alcohol lamp. A turbidity which develops on heating and continues to increase may be due to phosphates, serum-albumin, Bence-Jones albumin, nucleo-albumin, or albumose. If this turbidity disappears in a large measure or altogether when the boiling-point is reached, albumose or Bence-Jones albumin is present. When the specimen is boiling, a few drops of nitric acid are added, which will dissolve the phosphates and increase the turbidity due to serum-albumin. Comparison with the lower part of the test-tube containing

the urine which has not been heated will show faint traces, especially if a black screen is held between the test-tube and the light. On cooling, the turbidity due to mucin, albumose, or Bence-Jones albumin recurs. If a reaction other than that for serum-albumin has been obtained, it must be corroborated by specific tests.*

The **nitric-magnesium test** is a cold test, made by contact of the urine with the reagent. This may be made in any one of the many ways taught in the laboratory, but the albuminometer shown in the accompanying cut (Fig. 54) is a handy instrument for this test and can also be used for the numerous other contact tests made by the clinician. The clear glass instrument is preferable to one with a black and a white background painted on it. The clear filtered urine is poured into the large tube until this is about half full. The reagent is poured into the small funnel-end tube until this is not quite full. The latter makes its way beneath the former and a clean line of contact results. Serum-albumin shows a turbidity *at* the junction of the urine and reagent. Mucin or albumose shows an opalescent, not clearly defined turbidity *above* the junction, in the urine. These reactions are more clearly seen by placing any black object behind the instrument.

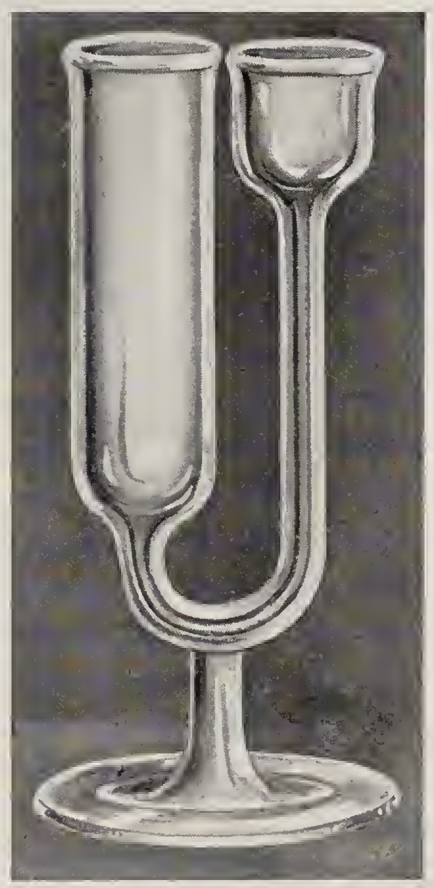


Fig. 54.—Albuminometer.

The nitric-magnesium reagent is made as follows:

Saturated aqueous solution magnesium sulfate. .	100 c.c.
Nitric acid.	20 c.c.

The **quantitative determination of albumin** if absolute accuracy is essential, is a rather tedious laboratory procedure. For clinical purposes, however, this is rarely necessary, and the results obtained by use of the Esbach albuminometer (Fig. 55) meet most of the requirements. The method is very simple, and is briefly as follows: The tube, as shown in the illustration, is filled to the mark U with filtered urine, acidulated if necessary with acetic acid, and then filled to the mark R with reagent. It is closed with a rubber stopper, inverted twelve times, and set aside in a cool place for twenty-four hours in a vertical position. The amount of albumin is read from the scale, which indicates grams per liter, or parts per thousand *by weight*. The specific gravity of the urine should be not higher than 1010, and the amount of albumin present should not exceed 4 per mille (parts per thousand) by weight—if it exceeds this the specimen should be diluted with water. It is a good plan to make a preliminary examination in an ordinary test-tube to estimate approximately the amount of albumin and exclude the presence of a considerable amount of albumose which is redissolved by heating the mixture. If considerable albumose is present, the method should not be used.

Esbach's reagent is made as follows:

Picric acid (c. p.).	5 grams
Citric acid.	10 grams

Dissolved in distilled water 500 c.c. and filtered.

* For a detailed description of these tests the reader is referred to Simon's "Clinical Diagnosis," 5th edition, 1904, or to some other good work on clinical chemistry.

GLUCOSE AND ALLIED SUBSTANCES

In routine work these substances are likely to be recorded simply as sugar, whereas one or another of the usual tests for glucose also responds to other substances. This matter is of interest to the surgeon, as the presence of glucose in the urine is often the first sign he has of the existence of a complicating true diabetes. Glycuronic acid and pentose are chiefly of interest, as these also respond to the copper test, and may mean only a slightly disturbed body metabolism.

In testing for **sugar** in a routine way, two methods should be used, the copper test and the bismuth test. Fehling's solution is the copper test commonly employed, but it is objectionable because it must be kept in two solutions and needs mixing up for use, whereas Haines's solution is an equally sensitive test, needs no dilution, and keeps for a long time.

Fig. 55.—Esbach Albuminometer.

Haines's test is made as follows: A few drops of urine are added to a dram of reagent and boiled. If sugar is present the characteristic copper reduction takes place.

Haines's solution is made as follows:

Cupric sulfate (c. p.)	3.0
Glycerin, pure	23.0
Distilled water	250.0
Dissolve and add potassium hydrate, pure	11.0

The **bismuth test** needs no comment. Both tests are made more sensitive by placing the tubes in a water-bath after simple boiling shows no reaction.

The **quantitative estimation of glucose** is usually made by means of the fermentation test or Fehling's test. The objection to the former is the time required, and to the latter the indefinite end-reaction. The **Rudisch quantitative test** is recommended on account of its simplicity and accuracy: 1 c.c. of urine measured with a volumetric pipet is placed in a 500 c.c. Erlenmayer flask and 100 c.c. of distilled water are added. This is placed on a tripod with a white background, and heated. On boiling, the reagent is added in small amounts from an ordinary or a Bincks buret, until the faint blue color does not disappear on two minutes' boiling. Each cubic centimeter of reagent used equals 0.0011 gram of sugar in 1 c.c. urine. The result multiplied by 100 gives the percentage, or the result multiplied by the number of cubic centimeters of urine voided in twenty-four hours gives the amount in grams of glucose excreted in twenty-four hours.

Example: 3000 c.c. urine voided in twenty-four hours.

Test shows use of 23.2 c.c reagent.

$23.2 \times 0.0011 = 0.02552$ gram glucose in 1 c.c. $\times 100 = 2.552\%$.

0.02552 gram glucose in 1 c.c. $\times$ 3000 c.c voided $= 76.56$ grams glucose excreted in twenty-four hours.

The volumetric sugar test solution is made as follows:

Cupric sulfate cryst.	4.78	grams
Sodium sulfite cryst.	50.0	grams
Sodium carbonate cryst.	80.0	grams
Ammonia water (10%), to make	500	c.c.

In order to exclude glycuronic acid or pentose, which would also respond to the above tests, a fermentation test is made. If this is positive, glucose is present; if it is negative and the copper and bismuth tests were positive, glycuronic acid or pentose is present. For corroborative tests for these substances the reader is referred to special works.

UREA

While the value of the knowledge of the daily excretion of urea has been the subject of much discussion, it is certainly true that a quantitative test for urea made on a single specimen passed at any time of day is an absolutely useless procedure. The really absurd record of grains of urea per ounce must be replaced by a statement of grams excreted in twenty-four hours, and even then the clinical value is not nearly so great as we formerly supposed. The textbook statement that a healthy male excretes from 25 to 40 grams of urea in twenty-four hours is also wrong. From 16 to 28 grams are much more correct figures, and from the surgeon's point of view an average of 16 grams should be considered the normal minimum.

CHLORIDS

In the efforts to determine renal functional ability by the new methods devised for this purpose the quantitative estimation of the chlorids in the urine has assumed new importance. In this connection it is well to state that the method by direct titration with decinormal solution of $AgNO_3$ is very faulty, and, in order to secure results which merit any consideration, the method by incineration or other more accurate procedure must be used.

MICROSCOPIC EXAMINATION OF URINE

The great value of the centrifuge for precipitation of the sediment, aside from its time-saving advantage, is established. While it would be folly to belittle the information gained from the character of the epithelial cells in a urinary sediment, too zealous effort to establish the origin of individual cells or groups of the same must be discouraged, and the opinion as to the character and seat of a lesion is better if based on the many characteristic general, chemic, and microscopic features presented by the specimen.

FUNCTIONAL DIAGNOSIS

This name has been given to a variety of procedures the aim of which is to determine whether the kidneys are doing normal excretory work. Much of what has been advocated has proved decidedly useful, though not infallible. The most important procedures advocated at present are the following:

- Cryoscopy of the blood, to determine molecular concentration.
- Cryoscopy of the urine for the same purpose.
- Inducing artificial glycosuria, separate collection of urine from each kidney, and examination.
- Ingestion of anilin dyes for the same purpose.
- Thorough analysis of twenty-four hour specimen of urine, preferably repeated.

Cryoscopy of the Blood, to determine its molecular concentration, is accomplished by learning the depression of its freezing-point as compared with that of distilled water. The normal molecular concentration of the blood causes it to freeze at minus 0.56° C., the freezing-point of distilled water being zero. In renal insufficiency the solids which should normally be excreted are retained in the circulating blood in abnormal amount, increasing its molecular concentration and thus lowering its freezing-point. This procedure is of very decided value to the surgeon as an aid in diagnosis and prognosis, and merits the consideration on this side of the Atlantic that it enjoys in continental Europe. It is an important factor in the prognosis when a diseased kidney is to be removed; it lends much weight in deciding whether a kidney should be removed or not; it forms an important element in the prognosis after one kidney has been removed, and it is of decided value in estimating the functional ability in bilateral kidney disease, thus influencing the prognosis of any operative procedure on persons thus afflicted. A normal freezing-point of the blood indicates normal renal excretory ability; if one kidney is diseased or destroyed, the other is doing the compensatory work. A reduction in the freezing-point to minus 0.58° C. or minus 0.61° C. indicates that both kidneys are unable to excrete solids properly. These data should be corroborated by all available methods, just as in other diagnostic and prognostic investigation.

Cryoscopy of the Urine, to determine the molecular concentration of the twenty-four hour specimen, was at one time advocated as an additional guide in estimating functional renal ability, but experience teaches that the wide variations met in health and disease without renal insufficiency (minus 0.9° C. to minus 2.0° C.) make a trustworthy conclusion based on this procedure a difficult and scarcely feasible matter. This test, applied to specimens of urine separately collected from each kidney, furnishes much more satisfactory results that are of great help in determining which is the diseased kidney, and in estimating the degree of its functional impairment. The decreased molecular concentration noted in the specimen obtained from the diseased kidney is often much more marked than the decreased specific gravity and the lowered relative amount of urea and chlorids would lead one to believe. The ordered intake of an unusual amount of fluid before ureter catheterization makes the procedure less tedious to both surgeon and patient, but it jeopardizes the value of the subsequent analysis and absolutely destroys the significance of cryoscopy of these specimens, as the healthy kidney may excrete water more rapidly than the diseased one, though the latter is comparatively impervious to solids. Even the polyuria of neurotic persons, under the circumstances, should be inhibited as far as possible by a sedative or narcotic. (The technic of cryoscopy is detailed below.)

Inducing Artificial Glucosuria.—The method of inducing artificial glucosuria, separately collecting urine, and determining the percentage of sugar excreted by each kidney is also used as a guide to functional ability. Phloridzin, 0.005 gram, is given by hypodermic injection before ureter-catheterization. This method never gained popularity in America and no longer enjoys universal support abroad. Requiring the patient to ingest methylene-blue or other anilin dyes, and observing the time intervening before the color appears in the urine, as well as the intensity of the color, or separately collecting the urine from each kidney and afterward comparing the specimens, is another method

which indicates the degree of functional ability. This method never had a scientific basis and has been largely abandoned. **Electric conductivity of the urine and blood** has been advised as an additional means of estimating functional ability of the kidneys, but as the results are also based on molecular concentration, they are for practical puroses identical with cryoscopy. **Uro=toxic coefficent** (Bouchard) is not yet sufficiently precise to be recommended as a practical procedure, to say nothing of the difficulties attending the use of the method.

Conclusions.—A perfectly normal urine, including normal daily excretion of urea and chlorids, justifies the conclusion that proper elimination exists. If corroborative evidence is desired for any reason, such as severe operative interference, or if a previous renal lesion creates a doubt, cryoscopy of the blood should show normal figures.

In unilateral renal disease indicating a nephrectomy the following steps to determine functional ability are indicated and materially aid in determining the advisability of operation and the prognosis. If a twenty-four hour specimen of urine contains at least 16 grams of urea, and if the freezing-point of the blood is normal (minus 0.56° C.), it is evident that the sound kidney is capable of compensatory elimination and the diseased one can be removed with safety. Separate collection of urine from each kidney by ureteral catheterization or other means and the demonstration by cryoscopy, specific gravity, relative amount of urea and chlorids, that the diseased kidney is doing but little excretory work compared with the sound one, strengthens the above conclusion. A diminution in the daily excretion of urea below 16 grams, and any increase in the molecular concentration of the blood shown by a lower freezing-point (minus 0.58° C. to minus 0.61° C.), indicates that both kidneys are unable to eliminate properly and that the removal of one is a far more serious matter. Kümmell and others consider a daily excretion of urea below 16 grams, and a blood freezing-point of minus 0.59° C. absolute counterindications to nephrectomy, and show greatly improved statistics of renal surgery in consequence.

Technic of Cryoscopy.—Either the Beckmann thermometer or the Heidenhain modification may be used. Both are graduated in hundredths of a degree Centigrade and the graduations are wide enough apart to allow readings of $\frac{1}{200}$ of a degree. Sufficient distilled water (10 to 20 c.c.) to cover the bulb of the thermometer is poured into a glass cylinder, and this cylinder is placed in another slightly larger one, so that an air space is made between the fluid and the freezing-mixture, which insures gradual cooling. The tubes are now put into the freezing-mixture of salt and ice and the thermometer into the fluid to be frozen, where it is held in place by a rubber stopper which also carries a platinum stirrer, bent in such a way as not to touch the sensitive thermometer.

The apparatus is most conveniently set up as shown in the accompanying illustration (Fig. 56), so that, by loosening the set-screw of the ferrule on the rod of the stand, the whole apparatus can be elevated above the level of the freezing-mixture in the glass battery jar. Constant stirring with the platinum wire is necessary; the mercury in the thermometer rapidly falls considerably below the freezing-point, when it suddenly jumps up, and momentarily rests *at the freezing-point*, which must be accurately noted. It now falls slowly to the temperature of the freezing-mixture. Several precautions must

be observed: (1) The freezing-point of distilled water as described above must be obtained before every examination. (2) The described jump of the mercury must occur if the technic is proper, when testing the water as well as when testing blood or urine; if it does not take place, the specimen has not been properly stirred. (3) The bulb of the thermometer must not come in contact with the container or the stirring wire. (4) The ⊔-shaped glass cylinder is preferable to a ∪-shaped large test-tube, as more thorough stirring is possible. The specimen to be examined is tested in the same way and the difference between the freezing-points obtained indicates the molecular concentration. For example, the freezing-point of distilled water under existing conditions of atmosphere and Beckmann thermometer is, we will say, 4.015° C., while that of a specimen of blood is 3.455° C.: 4.015 — 3.455 = — 0.56° C., the freezing-point of the specimen of blood. The blood is most conveniently obtained from one of the large veins at the bend of the elbow by means of an aspirator, or preferably by using Thatcher's "mosquito," shown in Fig. 57.

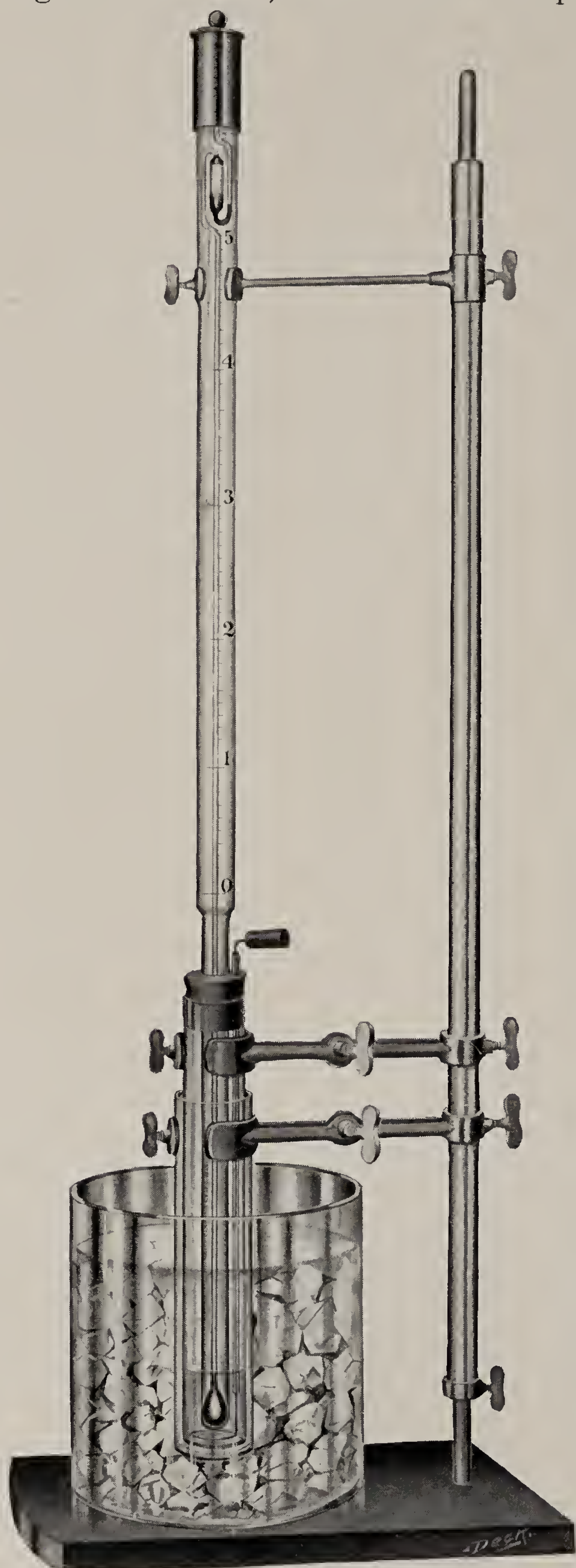


Fig. 56.—Apparatus for Cryoscopy.

Technic in Examining Small Amounts of Urine as Obtained by Ureteral Catheterization.—As the collection of urine under the circumstances is a tedious matter to both surgeon and patient, the analyst must arrange to obtain his information from very small amounts. With care and practice it is surprising how much can be done with little urine, and 10 c.c. of urine usually suffices, though every additional drop makes the procedure an easier one. The specific gravity is first taken with a Westphal balance, and the whole is then centrifuged to obtain the sediment for microscopic examination. After removal of the sediment, the whole may be accurately diluted with distilled water at a given temperature, and the amount is next divided for the tests for urea, chlorids, albumin, etc. Precision is essential, as errors are liable to be greater owing to the small amounts of the specimens used.

Hematuria, or the presence of blood in the urine, is a frequent symptom, the cause of which the surgeon is asked to determine. Clinical methods have made great headway, and the present universal use of the cystoscope makes the diagnosis a much easier one than it was twenty years ago. The characteristics presented by the urine are, however, worthy of close attention, and while its critical examination will not reveal the seat of the bleeding in every instance, much information of value is always obtained. That the more arterial the color of the blood, the lower in the urinary tract is its origin, is an old rule. This holds good except in some cases of severe hemorrhage from renal neoplasm, and in that seen in renal traumatism. In vesical, prostatic, and urethral hemorrhage the blood usually shows immediate tendency to coagulation, whereas in renal hemorrhage it is more intimately mixed with the urine and coagulates only when the bleeding has been profuse. In hemorrhage from the renal pelvis due to calculus, etc., unless very profuse, the blood is intimately mixed with the urine, and is much brighter in color than that in the smoky hematuria of acute inflammatory lesions of the renal parenchyma. The microscopic examination of the urine often shows evidences of the diseased condition which is the cause of the hemorrhage, and in this case it is reasonable to infer that the bleeding is of the same origin.

Fig. 57.—Thatcher "Mosquito."

Pyuria, or the presence of pus in the urine, is also a frequent symptom, the cause of which the surgeon is asked to determine. As in the case of hematuria, the cystoscope and other clinical methods are of much value in the diagnosis. The methodic analysis of the urine is also an important feature, as shown below, and the structural elements accompanying the pus, as well as many general characteristics presented by the twenty-four hour specimen, usually justify an inference as to its origin. Pus of vesical or prostatic origin usually undergoes coagulation quite rapidly, while that from the kidney is more intimately mixed with the urine and remains diffused throughout the specimen.

Post-anesthetic nephritis is today a much less frequent condition than it was fifteen years ago, an improvement which can doubtless be ascribed to the more careful use of anesthetics, quicker operating, the free administration of water by mouth or rectum after operation, and proper early attention to the bowels. There are but few cases in which a faint trace of albumin with or without few hyaline or epithelial studded casts cannot be demonstrated after anesthesia, due to some renal hyperemia. Comparatively few cases present all the characteristic evidences of an acute toxic nephritis. Diminished quantity of urine, high specific gravity, high relative and low absolute excretion of urea and chlorids, the presence of albumin, often in large amount, with a profuse sediment consisting of blood, a few pus-cells, and all varieties of casts, are the prominent symptoms. If the patient's general condition is good,

post-anesthetic nephritis usually responds to treatment more quickly than in the case of nephritis as ordinarily met with in medical practice. Every surgeon of considerable experience recalls a case in which the use of an anesthetic was followed by an absolute anuria and death. Pathologic examination reveals an intense hyperemia, but this seems scarcely sufficient to explain the clinical condition, especially if the patient presented no evidences of a previous renal lesion.

Acute and Chronic Nephritis and Its Influence in Surgical Prognosis.—This is a question which not infrequently confronts the surgeon, and while the clinical manifestations of this complicating disorder merit close attention, much information is obtained by laboratory methods. A thorough and preferably repeated examination of the urine, not omitting quantitative determinations of the daily amounts of urea and chlorids, offers a good guide to the status of excretory ability. The more recently advocated cryoscopy of the blood can be warmly recommended, and if the freezing-point is found below minus 0.56° C., the prognosis of the contemplated surgical procedure becomes affected in direct proportion to the freezing-point depression. Chloroform employed as an anesthetic is less irritating to the kidney than ether, but any anesthetic agent is liable to produce some exacerbation of the renal inflammation.

Diabetes Mellitus and Its Influences in Surgical Prognosis.—The presence of true diabetes as distinguished from simple glucosuria, glucuronic aciduria, and pentosuria, always exerts a decided influence on the prognosis in contemplated operative interference. It is a serious error to judge the severity of this disease by the percentage of glucose, or the quantity of sugar excreted in twenty-four hours, as the most dangerous cases sometimes excrete a comparatively small amount of glucose at the time. Careful examination for evidences of acid intoxication, as shown by the presence of acetone, diacetic acid, and beta-oxybutyric acid, must be made, as this constitutes the best guide in determining the prognosis. The patient who is excreting a large amount of glucose without acetone or diacetic acid in the urine, is a much better subject for the surgeon than the patient who shows but very little glucose with larger amounts of acetone, diacetic and beta-oxybutyric acids.

Evidences of Toxemia, Before and After Operations.—A fairly constant train of symptoms is at times associated with surgical lesions which cannot be referred to the pathologic process, and is now ascribed to faulty metabolism or toxemia. The causative factor is unknown, but the clinical manifestations are, briefly, severe headache, malaise often amounting to somnolence, and vomiting, usually with considerable nausea. It was originally believed that all these symptoms were referable to some local disorder in the stomach or bowel, and while it is true that the toxin may originate there, a cause for such development is not apparent. The evidences in the urine would tend to divide the cases into two classes: (1) A decided increase in the daily amount of uric acid, as shown by a lowered urea and uric acid ratio, and the presence of acetone, diacetic acid, and sometimes beta-oxybutyric acid. (2) A decided increase in the daily excretion of indoxyl sulfate and skatoxyl sulfate, as shown by pronounced indican and skatol reactions in the urine and a lowered ratio of mineral and ethereal sulfates. A combination of both is, however, frequently seen, and, as a rule, the first described class presents the most pronounced symptoms.

Acute Cystitis.—The daily amount of urine, the density, and the daily excretion of solids are normal, and the amount of albumin present corresponds to what might be accounted for by the blood, pus, etc. A microscopic examination of the sediment shows blood, pus, mucus, and many epithelial cells referable to the bladder. At first the reaction is usually acid, but it may become alkaline with the addition of triple phosphates in the deposit, unless the colon bacillus is the causative factor, in which case it remains acid and has an offensive odor. Elements of other causative factors can also usually be demonstrated.

Chronic Cystitis.—The urinary picture is much the same as in acute cystitis, but there is usually no blood present. If the lesion is tuberculous or due to the colon bacillus, the reaction is usually acid, but otherwise an alkaline fermentation develops in the bladder and many triple phosphate crystals will be found in the sediment, the specimen having a very offensive odor.

A differential diagnosis of chronic cystitis and pyelitis with hyperemia of the renal parenchyma is not always easy, because a cystitis so frequently accompanies the pyelitis.

	Chronic Cystitis.	Pyelitis with Hyperemia.
Daily amount of urine	Normal.	Increased.
Specific gravity	Normal.	Lowered.
Daily amount of solids	Normal.	Normal.
Reaction	Alkaline.	Acid.
Albumin	According to amount of pus.	More than pus would account for.
Sediment	Coagulates quickly.	Diffuse, not coagulated.
Renal elements	None.	Few casts, and epithelial cells from pelvis.

Pus due to cystitis always shows many structural elements referable to the bladder, while pus due to pyelitis shows but few epithelial cells at best.

Acute Catarrh of the Renal Pelvis.—The urinary picture is somewhat different according as this lesion is due to a local cause or to an ascending infection. In the event of a local cause, such as calculus or pronounced crystalline deposits, the daily amount of urine is decreased, there is corresponding concentration, normal daily output of solids, blood-cells according to the amount of local abrasion, few leukocytes, some mucus, characteristic groups of epithelial cells, and an amount of albumin and casts according to the degree of hyperemia of the parenchyma, some evidences of which invariably accompany the condition. In the event of an ascending infection, pyogenic, gonorrheal, or colon bacillus, the urine, showing the evidences of the original bladder lesion, suddenly becomes scanty, with some increase in the amount of albumin, the presence of few casts, and, if one is fortunate enough to recognize them, epithelial cells referable to the renal pelvis, with a normal daily output of solids. In either case this condition does not last long; the evidences of the acute catarrh disappear or the picture soon becomes that of pyelitis.

Pyelitis with Hyperemia of the Renal Parenchyma.—The daily amount of urine is increased, the specific gravity lowered, and the daily excretion of the solids is normal. The microscopic picture shows pus in addition to the elements found with catarrh of the pelvis. The pus usually also shows the characteristics of its renal origin, as detailed under the heading of Pyuria.

Pyelonephritis.—The twenty-four hour specimen of urine presents features similar to those noted in pyelitis, with the addition of the elements referable to the lesion of the parenchyma, *i. e.*, an increased amount of albumin and a greater number and variety of casts, though, as in other forms of chronic nephritis, there may be but very few casts at times. In the event of compensating excretory action of the other kidney, which always exists in unilateral renal lesions, the daily excretion of urea and chlorids remains normal or nearly so. Some of the specific varieties of pyelonephritis are considered in greater detail below.

Hydronephrosis and Pyonephrosis.—If the ureter on the affected side is occluded, the urine voided may be perfectly normal, but there is usually a moderate polyuria with evidences of a slight hyperemia of the renal parenchyma due to the additional excretory labor on the part of the acting kidney. An intermittent hydronephrosis, especially if there is an accompanying hematuria, which is by no means rare, presents a urinary picture which is more likely to confuse the diagnosis than to aid it.

A pyonephrosis suddenly emptying into the bladder also presents a very meager microscopic picture, but the necrotic character of the pus is often corroborative evidence, though a differential diagnosis of this condition and an abscess perforating into the upper urinary tract is most difficult.

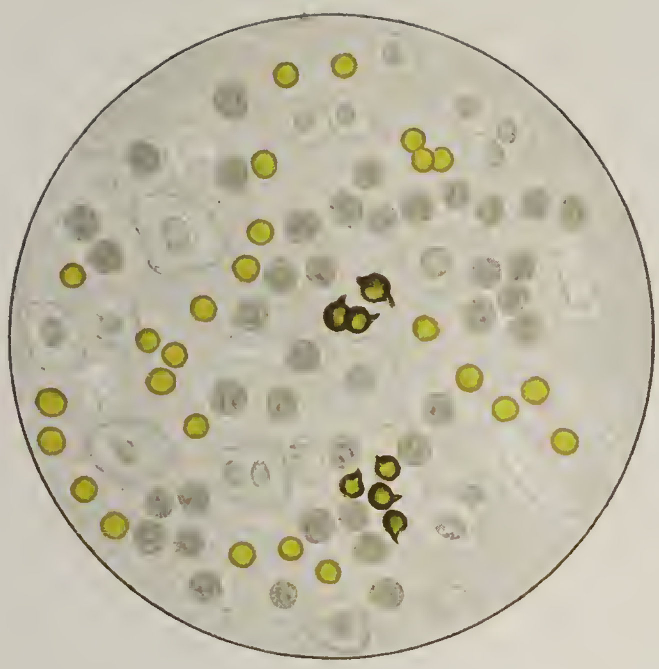
Polycystic Degeneration of Kidney, Syphilitic Renal Hyperplasia Simulating Malignant Growth, and Cysts of the Kidney.—In these cases there is usually very little or nothing in the urine analysis of value in the specific diagnosis. They present the evidences of the type and severity of the accompanying chronic nephritis which frequently but not invariably exists.

Renal Actinomycosis.—The urine presents the features of pyelitis with hyperemia of the parenchyma, or those of pyelonephritis with more or less frequent hematuria of renal origin. Much patience is necessary in identifying the fungus and thus establishing the diagnosis, for this is usually no easy matter even for the expert microscopist.

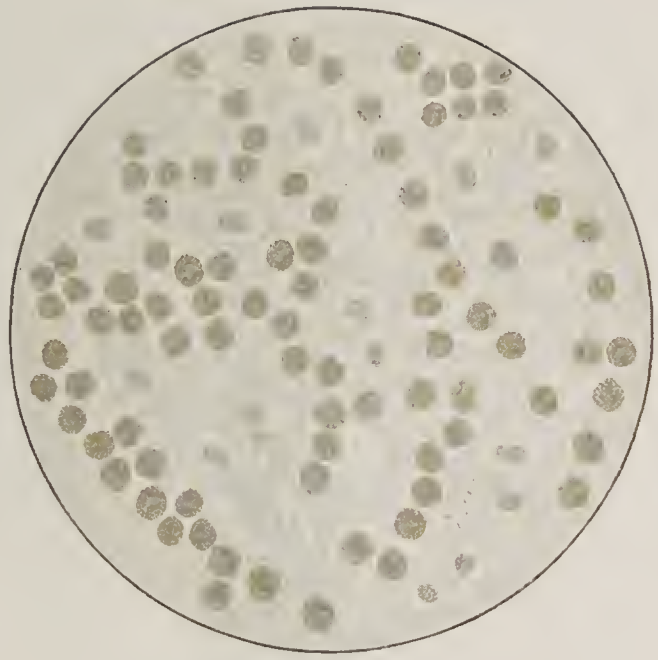
Floating Kidney.—An examination of the urine discloses no characteristic features, but frequent attacks of transient neurotic polyuria are observed in some cases.

Malignant Tumors of the Kidney.—An intermittent renal hematuria, often of very brief duration, is the most constant abnormal feature in the urine. The hematuria is usually quite profuse, and in consequence may present clots and even casts of the ureter or pelvis. In typic cases the urine is otherwise normal, or perhaps more frequently shows the evidences of a slight hyperemia of the renal parenchyma. The presence of microscopic blood between the attacks of pronounced hematuria is a very suggestive feature. Even if the hemorrhage is quite slow, the blood looks red, and is not smoky, as in acute nephritis. The coexistence of pyelitis or pyelonephritis is really foreign to the condition under consideration, and when present is brought about by an ascending infection, perhaps due to lack of resistance on the part of the mucous membrane, or is the result of a local suppurating lesion in the tumor. A few cases present marked albuminuria without corroborative evidence of nephritis in the remaining healthy parenchyma. In fact, the urine analysis in cases of this kind teaches less of diagnostic value than is usually ascribed to it. When sufficiently preserved shreds of tumor are passed, the

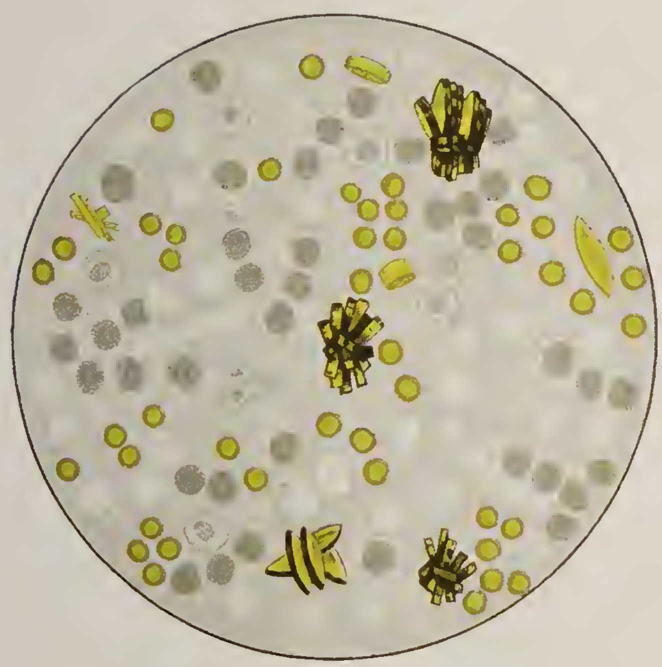
PLATE IV



A



B



C F.A.DECH. fecit

D

TYPIC URINARY SEDIMENTS IN THE FOLLOWING CONDITIONS:

A. Acute cystitis. Blood, pus and mucus. Note the large number of epithelial cells.

C. Acute pyelitis and hyperemia of parenchyma due to stone colic. Blood, pus, very little mucus, and few hyaline casts with decided oxalate of lime crystalline deposit. Note the comparatively few epithelial cells.

B. Chronic cystitis. Pus with much mucus. Note the large number of epithelial cells.

D. Chronic pyelonephritis with colon bacillus bacteriuria. Pus, but little mucus, numerous hyaline and granular casts and bacteria. Note the comparatively few epithelial cells.

conclusions are obvious, but this occurrence is by no means so frequent as the text-books would lead one to believe. An erroneous laboratory diagnosis of malignant tumor of the kidney based solely on the structure of one or a number of epithelial cells found in the urine has annoyed many a surgeon, the "cancer cell" and the "sarcoma cell" being myths for practical purposes.

Renal Tuberculosis.—With what is often the first clinical symptom —nocturnal frequency of urination—the urine may be perfectly normal in daily amount and chemic composition, the few blood-cells found microscopically constituting the only noteworthy feature apparent. The urinary picture very soon changes to that of pyelitis with hyperemia of the parenchyma, the rather marked polyuria and the presence of at least a few blood-cells being practically constant. Later the specimen presents all the evidences of pyelonephritis. The process of finding tubercle bacill in the sediment has been simplified by the introduction of the centrifuge, and success is largely due to the patient and painstaking search made for them. The cases of renal tuberculosis in which bacilli are not found when a number of specimens have been examined are not so numerous as usually believed, and the fault lies in lack of thoroughness in the investigation. There are cases, however, in which bacilli cannot be found on repeated careful search, and in these animal inoculation is often, though by no means invariably, successful. Tuberculous urine usually has an acid reaction and does not show a macroscopic bacteriuria. When a mixed infection does occur and the specimen is foul, an attempt should be made to get it into better condition before animal inoculation is undertaken. In the event of animal inoculation, experience teaches that the macroscopic result is not sufficient, but the presence of actual tubercles must be demonstrated microscopically. Concerning the differentiation of tubercle bacilli and smegma bacilli, the decolorization of the latter with absolute alcohol usually presents no difficulty, but in case of a marked alkaline fermentation the tubercle bacilli do not so well withstand the action of alcohol. An opinion based on the presence of single bacilli must be very guarded, but usually the organisms occur in groups which present specific characteristics, as shown in the accompanying illustrations. (Plate V.) The diagnosis of tuberculous renal disease can usually be made from the urine, and success is due rather to patient investigation than to particular skill.

Renal Calculus.—In this condition the urinary picture is most varied according to the pathologic process which has developed in consequence of the presence of the foreign body, and that due to a complicating infection. On the one hand, perfectly normal urine may be voided or there may be evidences of a slight hyperemia of the renal parenchyma; on the other, the most severe pyelonephritis and cystitis with a marked alkaline fermentation may be seen, in which it is often difficult to find any structural elements in the vast amount of very offensive coagulated pus and masses of triple phosphate crystals. At the time of a renal colic the picture is ordinarily that of an acute catarrh of the renal pelvis, with more or less hyperemia of the parenchyma, the amount of blood being in direct proportion to the mechanic injury. After the attack of pain these evidences disappear more or less quickly, or pyelitis is developed, to remain or gradually clear up as the case may be. In the chemic analysis of specimens from cases of renal stone the almost constant high relative as well as the absolute nitrogenous output is a noteworthy feature which can be

looked to with considerable success as an important point in differential diagnosis. It stands to reason that a patient whose mode of life has been suitably corrected does not present these characteristics, or presents them only to a moderate degree. The presence in the urine of pronounced crystalline deposits, while forming a link in the chain of evidence, justifies conclusions in only a small number of cases. Triple phosphate deposits are the result of an alkaline fermentation due to any cause, and merit no consideration in this connection. An intermittent hydronephrosis often empties with a colic and frequent micturition, and at this time is liable to show some blood. The differential point between this colic and a stone colic is, that in the former the amount of urine is usually large and the gravity low, whereas in the latter the opposite is an almost invariable rule.

Nephralgia and Allied Conditions.—The etiology of these conditions is still a subject of dispute, and the urinary findings often closely resemble those noted in other lesions, so that a differential diagnosis is difficult at best, and at times impossible. The absolutely pessimistic view held by many is due to the negative outcome of one or two specimens, while the clinical examination has been repeated over and over with no better result. Careful and often repeated analysis, while possibly leading to no positive result, tends to exclude other conditions, and is oftentimes of greater practical utility than all the clinical work. During an attack of nephralgia the urine may be perfectly normal, but this is also true in renal colic due to stone, though much less frequently. A neurotic polyuria may occur at the time of a nephralgic paroxysm, whereas no simulating condition is noted in stone colic. On the other hand, cases of nephralgia with hematuria and scanty urine are not unknown, but experience teaches that they never show the almost immediate evidences of an inflammatory lesion noted in the same condition due to calculus.

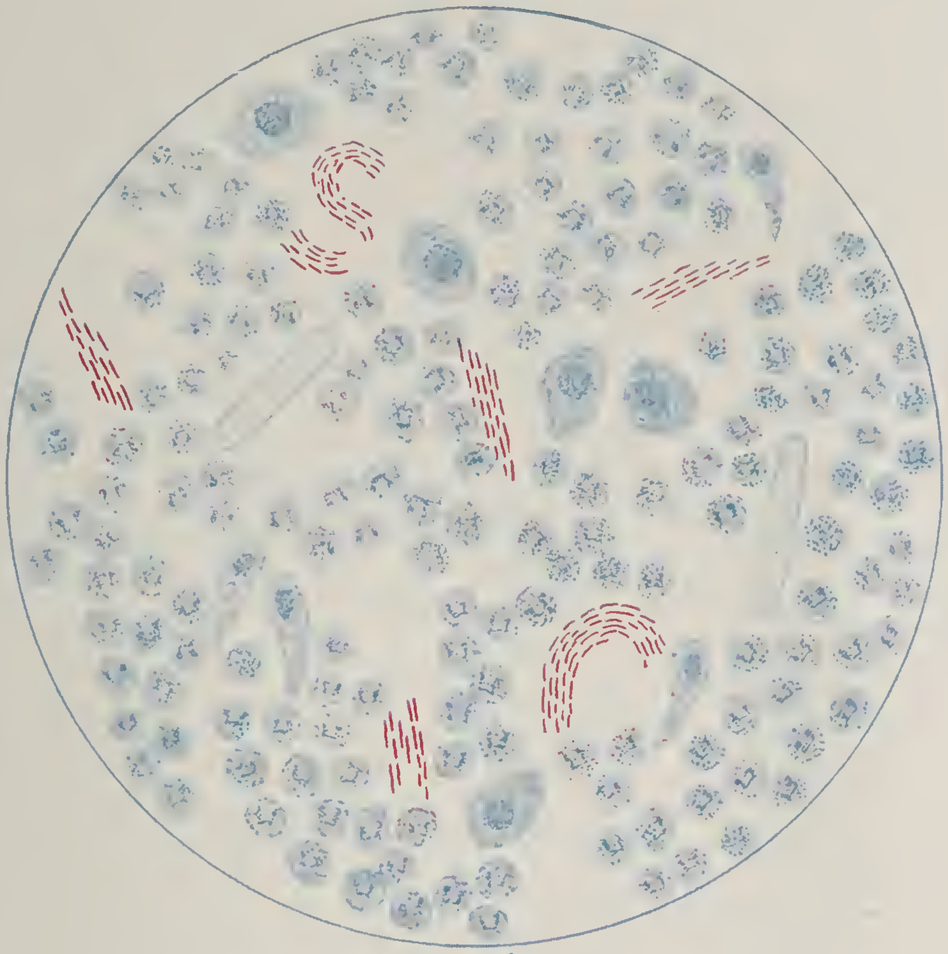
Hematuria Due to Atrophic Kidney.—The pronounced hematuria seen at times in this condition, as well as that noted in an acute exacerbation of an older renal lesion, the former red, the latter smoky, must be kept in mind when seeking the cause of a renal hematuria.

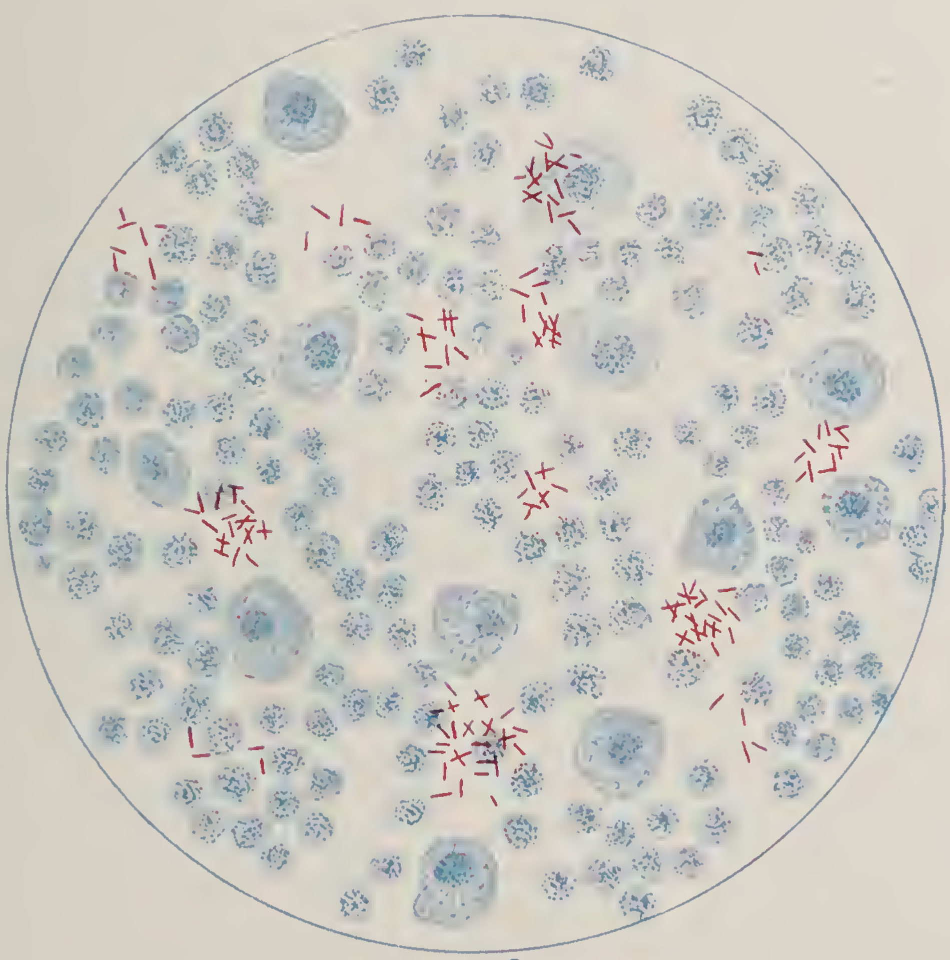
Subcutaneous Traumatism of the Kidney.—In subcutaneous renal injuries the first urine voided shows a pure hematuria, and the subsequent picture depends largely on the nature and the result of the lesion and on the presence or absence of a bacterial infection.

Suppurative Nephritis.—This name is frequently given to cases in which multiple miliary abscesses develop throughout the kidney in conjunction with an acute pyelonephritis due to streptococcus invasion. The urine shows the elements found in pyelonephritis, the clinical symptoms usually being more profound than the urinary picture would seem to justify. A careful examination of the bood presents the evidences of the severe septic process, and is often the cardinal indicator for the prompt surgical relief which these cases demand.

Colon bacillus infection of the urinary tract is a common occurrence, and may not only be the cause of a severe cystitis, but may result in a pyelonephritis as well. The urine shows the evidences of the existing lesions with an acid reaction, an offensive odor, and a macroscopically apparent bacteriuria. Direct culture attempts for diagnosis by stab inoculation of glucose agar should show a nonliquefying, offensive gas-producing growth, but the accurate differential diagnosis belongs to the domain of bacteriology.

PLATE V





A. Typic Groups of Tubercle Bacilli.
B. Usual Grouping of Smegma Bacilli.

SCHEMATIC TABLE OF URINARY PICTURE IN THE MORE IMPORTANT SURGICAL DISEASES OF THE URINARY TRACT.

Disease.	Daily Amount of Urine.	Specific Gravity.	Reaction.	Daily Amount of Urea.	Abnormal Constituents.	
					Albumin.	Microscopic.
Acute cystitis.	Normal.	Normal.	Acid, occasionly alkaline.	Normal.	Equal to amount, pus and blood.	Blood, pus, mucus, and many bladder epithelial cells. Evidences of the causative factor.
Chronic cystitis.	Normal.	Normal.	Alkaline unless colon bacillus or tuberculosis.	Normal.	Equal to amount of pus, etc.	No blood, otherwise as above. Also bacteria, and if alkaline, triple phosphates. Evidences of causative factor.
Acute catarrh of renal pelvis with hyperemia of the parenchyma.	Decreased.	High.	Acid.	Normal or diminished. Usually increased if stone.	More than blood and pus would account for.	Blood, pus, few pelvic epithelial cells, few hyaline or epithelial casts. Hematuria with stone colic. Evidences of causative factor.
Pyelonephritis.	Increased, particularly in tuberculosis.	Low.	Acid	Normal if unilateral, otherwise decreased. Usually increased if stone.	Considerably more than pus, etc., would account for.	No blood, otherwise as above. Larger number of casts also granular. In tuberculosis and neoplasm usually few blood-cells, occasionally hematuria. Evidences of causative factor.

EXAMINATION OF SPUTUM

Specimens must be considered both macroscopically and microscopically; the former may show a typic picture of pulmonary gangrene by the offensive odor and the presence of pieces of necrotic tissue, while the latter may give the

first indications of pulmonary tuberculosis. The following conditions are those of chief interest to the surgeon:

Hemoptysis due to perforating aneurism may present simply a large amount of arterial blood, with or without the history of a previous catarrhal condition due to pressure and necrosis. An eroded carotid artery rupturing into an open retropharyngeal abscess presents the same picture.

Abscess of Lung.—The expectoration may consist solely of pus, with little or no odor, which is raised in very large amounts, often as much as a pint in twenty-four hours, structural elements, blood-cells, elastic fibers, fat globules, crystals of fatty acids, etc., also being found microscopically. Staining usually shows many nonpathogenic organisms in addition to pyogenic forms, chiefly the staphylococcus. Chronic lung abscesses present much the same picture, with the occasional addition of cholesterin as seen microscopically, but no blood. In abscess of the lung evidences of actinomycosis and echinococcus should always be looked for.

Empyema Rupturing into the Lung.—The specimens as well as the sudden manner of expectoration resemble what is seen in abscess of the lung, and a differential diagnosis is oftentimes quite difficult. The amount of pus expectorated at one time is seldom as large as noted in abscess, but the daily amount may be larger.

Echinococcus cysts in the liver sometimes perforate into the pleura and in turn into the lung. The sputum has a peculiar yellow color and the evidences of echinococcus are usually easily found.

Neoplasm of the Lung.—The sputum is likely to contain small or large amounts of blood, and the presence of microscopic blood between the more profuse hemorrhages is a suspicious sign. Very rarely indeed sufficient tumor tissue is expectorated for diagnostic purposes, and a warning must be sounded against so-called "carcinoma cells."

The characteristics found in the sputum in pulmonary tuberculosis, pneumonia, bronchitis, etc., belong to the domain of general medicine.

EXAMINATION OF GASTRIC CONTENTS

When the modern methods of gastric analysis resulted in greater accuracy in the diagnosis of diseases of the stomach, it was believed that the two diseases which particularly interest the surgeon, namely, ulcer and cancer, could be positively diagnosed at an earlier period in the laboratory than by clinical means. The absence of hydrochloric acid and the presence of lactic acid were considered positive indicators of carcinoma, while the presence of an excessive amount of hydrochloric acid indicated ulcer. Time proved that this rule, like most others, had its glaring exceptions, and the opinion of today is that the result of the gastric analysis must take its place with the clinical signs and symptoms, to be considered for what experience has taught it is worth.

The procedure is as follows: The patient is given an Ewald test breakfast consisting of one baker's roll without butter, weighing about 35 grams, and 300 c.c. of water or weak tea without milk or sugar, on an empty stomach. One hour after ingestion the contents of the stomach are expressed by tube without the use of water. While a more elaborate examination may be useful, at least the following determinations should be made:

Total quantity (normal, 40 c.c. to 200 c.c.).
Total quantity of filtrate (normal, 20 c.c. to 140 c.c.).
Free hydrochloric acid (normally present).
Lactic acid (normally absent).
Total acidity (normal, 1.5 to 3.0 grams per mille). Scheme "A."
Total hydrochloric acid (normal, 1.15 to 2.48 grams per mille). Scheme "E."
Total free hydrochloric acid (normal, 0.09 to 1.9 grams per mille). Scheme "D."
Total combined hydrochloric acid (normal, 0.24 to 1.49 grams per mille). Scheme "C."
Total acidity due to organic acids and acid salts (normal, 0.2 to 0.88 gram per mille). Scheme "F."

Presence of free hydrochloric acid (*vide infra*) is most easily demonstrated with Töpfer's test. The addition of one or two drops of 0.5 per cent alcoholic solution of dimethyl-amido-azo-benzol to a small amount of gastric contents immediately produces a bright cherry-red color if free hydrochloric acid is present. This test is preferable to others on account of its delicacy and the stability of the reagent. Lactic acid if present in considerable amount will produce an orange color, but if any doubt exists the lactic acid can be removed by treating the specimen with ether before the test for free hydrochloric acid is applied.

Presence of lactic acid in sufficient amount to be of clinical importance can be demonstrated by the Strauss test. The graduated separating funnel shown in the illustration (Fig. 58) is filled to the 5 c.c. mark with filtered gastric contents, pure ether is added to the 25 c.c. mark and this is thoroughly shaken. After the liquids have separated the stopcock is opened, and all but 5 c.c. allowed to escape. Distilled water is now added to the 25 c.c. mark, shaken, and followed by 2 drops of the reagent, consisting of a freshly made 1 to 10 dilution of tincture of ferric chlorid in water. The presence of lactic acid is shown by a decided green color.

Fig. 58.—Strauss Graduated Tube for Lactic Acid Determination.

SCHEMES

"A." **Total acidity.** To 10 c.c. filtered gastric contents add 2 drops of 1 per cent alcoholic solution phenolphthalein (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 7 c.c. $\frac{1}{10}$ N. NaOH used. $7 \times 0.00365 = 0.0255$ gram total acidity in 10 c.c. gastric contents expressed as HCl. $0.0255 \times 100 = 2.55$ grams total acidity per mille (per thousand).

"B." **Free acids and acid salts.** To 10 c.c. filtered gastric contents add 2 to 3 drops 1 per cent aqueous solution sodium alizarin sulfonate (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 4.9 c.c. $\frac{1}{10}$ N. NaOH used. $4.9 \times 0.00365 = 0.0178$ gram total free acids and acid salts in 10 c.c. gastric contents expressed as HCl. $0.0178 \times 100 = 1.78$ grams total free acids and acid salts per mille (per thousand).

"C." **Total combined hydrochloric acid.** "A" as above 2.55 minus "B"

as above 1.78 = 0.77 gram total combined hydrochloric acid per mille (per thousand).

"D." **Total free hydrochloric acid.** To 10 c.c. filtered gastric contents add a few drops 0.5 per cent alcoholic solution dimethyl-amido-azo-benzol (indicator). Titrate with $\frac{1}{10}$ normal sodium hydrate. For example, 3.1 c.c. $\frac{1}{10}$ N. NaOH used. $3.1 \times 0.00365 = 0.0113$ gram total free hydrochloric acid in 10 c.c. gastric contents. $0.0113 \times 100 = 1.13$ grams total free hydrochloric acid per mille (per thousand).

"E." **Total hydrochloric acid.** "C" as above 0.77 plus "D" as above 1.13 = 1.90 grams total hydrochloric acid per mille (per thousand).

"F." **Total acidity due to organic acids and acid salts.** "B" as above 1.78 minus "D" as above 1.13 = 0.65 gram total acidity due to organic acids and acid salts per mille (per thousand).

Some experience is necessary to determine the proper end reactions in the above.

EXAMINATION OF FECES

The macroscopic as well as the microscopic examination of the stool offers corroborative evidence in diagnosis, oftentimes of the greatest importance. The following résumé is limited to the features of particular interest to the surgeon.

Macroscopic Examination.—Hemorrhage from the lower portion of the bowel may show unchanged blood, while blood derived from the stomach or small intestine may be totally disintegrated and give the stool a dark brown or black color, a sticky character, and a very offensive odor. In obstruction to the outlet of bile the stool is clay-colored or grayish-yellow. In suspected cholelithiasis careful search should be made for concretions by stirring the feces with water and straining. Gallstones occur in all sizes, and usually consist of a mixture of cholesterin and bile pigment with salts. Pus and mucus derived from the lower portion of the intestinal tract are usually adherent to the fecal masses, but if derived from a higher portion, they are intimately mixed with the stool and may not be apparent macroscopically. Abscesses rupturing into the intestine usually show an easily recognized mixture of pus and blood in the stool.

Microscopic Examination.—The presence of ameba may corroborate a diagnosis of abscess of the liver. Evidences of parasites or specific bacteria often explain what seem to be obscure conditions.

Intestinal ulcerations in the small gut need not be accompanied by diarrhea, but those in the large intestine are always accompanied by it. The amount of pus found in the feces is no guide to the severity of the ulcerative process.

Intestinal tuberculosis usually shows the evidences of ulceration and tubercle bacilli are easily found. In referring tubercle bacilli found in the feces to intestinal lesions it must be remembered that swallowed tuberculous sputum may occasion the presence of bacilli in the stool. In examining feces for tubercle bacilli, the mucopurulent particles should be selected if they can be found. As smegma bacilli also occur in feces, the differentiation by alcohol must be made.

Carcinoma of the Intestine.—If the lesion is situated in the upper portion of the intestinal tract, the stool may present pus and altered blood intimately

mixed with it, the odor usually being very offensive. No significance can be attached to the "ribbonlike" appearance of the stool formerly considered pathognomonic. In carcinoma of the rectum small amounts of offensive blood, pus, and mucus are often voided with tenesmus without an admixture of feces, but the same occur in proctitis from any cause, though the offensive odor is not present unless there is a ruptured periproctic abscess. Tumor particles are seldom found, and a warning against the imaginary "cancer cell" is again sounded. Passage of masses of blood and mucus not offensive and without tenesmus is sometimes seen with intussusception.

In seeking a cause for intestinal hemorrhage, that due to scurvy and allied conditions must be kept in mind.

While the modern surgeon is interested in diseases of the liver and pancreas which alter the chemistry of the feces, the significance of this analytic work still belongs to the domain of general medicine.

EXAMINATION OF ASPIRATED FLUIDS

The chemic and microscopic examination of aspirated fluids is often of the greatest help in diagnosis, and careful work generally leads to the most gratifying results, which are of particular interest to the surgeon.

Transudates are usually straw-colored serous fluids of noninflammatory origin, though they may be tinged with blood, and they are of interest here on account of the differential diagnosis between them and the serous exudate of inflammation. This differential diagnosis is to be based on the characteristic features shown in the following table:

	Transudate.	Exudate.
Specific gravity	1005 to 1020.	1018 to 1030.
Coagulation	Unusual except when blood present.	Usually prompt and decided.
Albumin	1 to 45 per mille by weight.	40 to 80 per mille by weight.
Seromucin (on addition of acetic acid)	None or traces.	Pronounced reaction.
Microscopically	Few leukocytes and endothelial cells from the serous surface.	Characteristics as detailed under special headings and cytodiagnosis.

Exudates are usually serous, hemorrhagic, or purulent in character, and all are of inflammatory origin. If purulent, inflammatory origin is obvious, while the serous or the hemorrhagic exudate must be distinguished from a similarly appearing transudate by the means detailed above.

Cytodiagnosis or the microscopic study of the cellular elements not only aids in differentiating transudate and exudate, but promises to give much information as to the type and cause of the latter. The main feature is the predominance of the lymphocyte cell or of the polynuclear cell, and the presence or absence of other varieties of leukocytes. Owing to the recent development of this study the opinions are still divergent, but the following conclusions probably represent present-day belief.

In acute inflammatory exudates in the pleura of pneumococcic or streptococcic origin the polynuclear leukocyte usually represents 90 per cent of the total count, while in the early stage of tuberculous pleurisy the polynuclear

percentage is rarely 50, and as the disease progresses the polynuclear cells diminish in numbers and the lymphocytes represent as high as 90 per cent of the differential count.

In malignant disease of serous membranes the microscopic picture of the cellular elements in the exudate is often looked to for diagnosis. Many so-called characteristic features have been described and the differential diagnosis of cancer cells and endothelial cells is detailed by many. An erroneous diagnosis of cancer of the pleura is, however, a serious matter, and as long as the so-called pathognomonic cellular indications are disputed, it is well to accept a diagnosis on this basis with caution. The finding of tumor particles, which can be sectioned, stained, and examined, naturally leaves no room for doubt.

The significance of cytodiagnosis in cerebrospinal fluid will be detailed under the head of lumbar puncture.

Actinomycosis.—In purulent exudates with obscure etiology the characteristics of this fungus should be kept in mind when making the microscopic examination. Aside from the fungus, the specimens present nothing particularly worthy of note.

Putrid exudates are obtained from the pleural cavity when hepatic or subphrenic abscesses have perforated into this cavity, and are characterized by a brownish-green color and an extremely offensive odor.

Chylous exudates are observed usually in the abdominal cavity, but their significance depends largely on the clinical factors, and this examination lends little or no aid in the diagnosis.

Echinococcus Cysts.—The fluid obtained by aspiration is usually clear and shows numerous crystals of cholesterin in addition to the characteristic hooklets on microscopic examination. Small shreds of the typic laminated membrane as well as scolices may also be found.

Ovarian Cysts.—The obtained fluid is viscid in character, varies greatly in specific gravity as well as in amount of albumin present, and should respond to tests for metalbumin. The coagulable albumin is removed and the fluid filtered, when the addition of alcohol should result in a flocculent precipitate. Microscopically the specimens present red and white blood-cells, and occasionally cholesterin crystals and fatty granules. Cylindric ciliated epithelial cells from the lining membrane and colloid concretions are characteristic, but unfortunately not always present. The fluid obtained from cystic uterine tumors has a low specific gravity, is not viscid, and coagulates quickly, while that from parovarian cysts has much the same appearance but does not coagulate.

Hydronephrosis.—The differential diagnosis of fluid aspirated from an ovarian cyst and that aspirated from a hydronephrosis usually offers no difficulty. The latter is quite watery instead of viscid, contains little if any albumin, and notable amounts of urea and uric acid can be demonstrated. While the microscopic examination may be unsatisfactory, it frequently presents undoubted renal elements.

Hepatic Abscess.—In the microscopic examination of pus from this source a search for Ameba coli should not be neglected. The reminder that amebas are the cause of abscesses in other parts of the body may not be amiss.

Lumbar Puncture.—The increased value of this procedure as a diagnostic factor is noteworthy. The chemic and bacteriologic examinations of the cere-

brospinal fluid are decidedly useful, and cytodiagnosis, while still a disputed subject, promises some aid. The normal fluid is perfectly clear and colorless, has a specific gravity of about 1006, and contains approximately by weight 1 per mille of albumin. As the subject really belongs to general medicine rather than to surgery, with one exception the details have no place here. In apoplexy, and injuries of the skull extending through the dura mater, the blood may make its way into the lateral ventricles and appear on lumbar puncture, while extradural head injuries never present bloody cerebrospinal fluid.

SECTION VIII

SURGICAL OPERATIONS IN GENERAL

GENERAL CONSIDERATIONS

Every surgical procedure is productive of more or less risk to the life of the patient, and no operation should be entered upon without due consideration of the dangers which it entails, as far as the patient is concerned, to say nothing of the influence which the operation may have on the art of surgery itself or on the surgeon's reputation. Bearing this in mind, the surgeon will carefully weigh the benefits to be derived from the operation against the risks to be taken in order to secure these benefits, and he will see to it that a life is not unnecessarily placed in peril, or that unjustifiable risks are not taken, even at the patient's own request, for the correction of trifling conditions. On the other hand, the practitioner who hesitates, in the face of grave surgical emergency, to assume the responsibility which the circumstances demand, and to act promptly, as far as he is able, in order to save a life, will bring reproach on himself and opprobrium on his profession.

For purposes of consideration from the present standpoint surgical operations may be divided into (1) imperative operations; (2) operations of necessity; (3) operations of utility; (4) operations of expediency; (5) multiple operations; (6) unjustifiable operations.

Imperative Operations.—In this class may be placed those operations that are universally acknowledged as of urgent and immediate necessity, and in which the life-saving character of the procedure depends on the promptness of the execution.

As instances in this connection may be cited the following: abdominal section for gunshot and stab wounds involving the integrity of the intestinal canal or causing concealed hemorrhage; the ligation of arteries not accessible for the provisional arrest of hemorrhage; amputation for the removal of an extensively mangled and useless limb in which crushed nerve-trunks tend to increase shock, as well as amputation for the arrest of hemorrhage.

Operations of Necessity.—In this class may be mentioned those operations for the removal of malignant growths and other neoplasms, as well as for conditions which, though urgently demanding surgical interference, permit time and opportunity for due preparation.

Operations of Utility.—In this class of cases an effort is made to correct conditions which tend to prevent the patient from entering into the ordinary pursuits and enjoyments of life, even if they do not threaten or shorten his existence. As familiar instances of this class of operations may be noted plastic procedures for harelip and cleft palate; tenotomies and bone resections for clubfoot; operations designed to correct deformities which are the result of paralyses and contractures arising from diseases of the central nervous

system, as well as those due to injury; operations for the permanent fixation of flail joints (see Arthrodesis, page 372); tendoplasty for transferring a portion of the muscular force from active to paralyzed parts.

Operations of Expediency.—These are the so-called cosmetic operations, and are usually designed, as the name implies, to improve some unsightliness in the personal appearance of the patient. An instance of a purely cosmetic operation is that for projecting or protuberant ears. Certain operations in this class, while they are performed primarily for cosmetic purposes, yet serve a further and useful end, *e. g.*, the operation for ectropion of the eyelid, in which, in addition to the improvement of the patient's appearance, there is a restoration of the protective function of this structure to the globe.

Multiple Operations.—Operations on the pelvic floor of women who have borne children come more particularly under this head. In the majority of cases of parturient injuries the conditions demand for their relief several independent operative procedures, particularly if these are performed some time after delivery. These include curettage of the uterus for the chronic endometritis which is commonly present, trachelorrhaphy for the lacerated cervix uteri, and perineorrhaphy. In more aggravated cases, or those of long standing, anterior and posterior colporrhaphy may be necessary. Further, prolapse and retrodeviation of the uterus, as well as infections of the adnexa, may be present and demand hysterorrhaphy for the first named and oophorectomy and salpingectomy for the second. Finally, the presence of aggravated hemorrhoids is not uncommon in this class of cases. All of the above operations may be necessary in the same patient, and it becomes a question of judgment in each individual case as to how many and which of them shall be performed at one sitting.

Whenever several operations are performed on a patient at the same séance, care should be observed to conduct the several procedures in the order of their cleanliness. For instance, an operation for hemorrhoids should not precede an abdominal section. This rule does not always hold good, however. If a peritoneal suspension of the uterus or a salpingo-oophorectomy precedes a trachelorrhaphy, dragging on the uterus in the performance of the latter may nullify the hysterorrhaphy, or, in the case of the adnexal operation, cause the slipping of a ligature and the occurrence of concealed hemorrhage.

Unjustifiable Operations.—No self-respecting surgeon will perform an operation for the removal of healthy ovaries, the ligation of the Fallopian tubes, and similar procedures intended to prevent conception in a woman capable of bearing children; nor will he perform an operation designed to alter the personal appearance of an individual for the purpose of disguise or to enable him to escape punishment for crime.

COMMON DANGERS OF SURGICAL OPERATIONS

Excessive fear is to be mentioned in this connection. That the mental condition bears some relation to the occurrence of shock there can be no doubt, since it has been shown that stoically inclined individuals, and those hopefully inclined, as well as children and the insane, other things being equal, suffer comparatively little from shock.

The **administration of a general anesthetic** gives rise to certain immediate and well-defined risks, which should always be taken into account in this connection. These relate particularly to the effects of the anesthetic agent on the heart and respiratory apparatus, as well as to the dangers arising from mechanic causes, such as jaw spasm with the forcing back of the tongue so as to obstruct the glottic opening, which occurs in the case of ether anesthetization particularly, and the lodgment of foreign bodies, as false teeth, chewing-gum, vomited matter, etc., in the respiratory passages. Violent struggling on the part of the patient at the commencement of chloroform anesthetization leads to a most pronounced and rapid effect of the drug, and if its administration is persisted in under these circumstances, it may cause fatal narcosis. Want of proper care and watchfulness on the part of the anesthetist may also easily permit the latter to occur.

The **avoidance of hemorrhage** constitutes the most imperative duty of the operating surgeon. The careful and systematic clamping of each ordinary sized bleeding vessel as it is encountered, prompt finger pressure, and a properly directed effort to secure the bleeding point in the case of injury to a larger branch or main trunk form a very important part of the training of the skilled operator. While the loss of some blood is unavoidable during an operation, the aim should be to minimize this loss as much as possible consistent with the proper conduct of the operation, since, without due regard to this rule, the dangers from shock are greatly increased and the healing process is retarded. A considerable loss of blood extending over a longer period of time is better borne by the patient than the same quantity escaping by a sudden gush from a large trunk. Failure to institute prompt measures to compensate for the loss of blood when this is excessive may sacrifice the patient's life, even after arrest of bleeding is promptly and properly secured. The dangers of hemorrhage do not cease with the completion of the operation; the patient must be watched for subsequent bleeding up to the time when definite healing of the ligated vessels may be expected to occur (see page 88).

Shock.—This term is used to designate an extreme functional depression, first, of the nervous system, and, second, in consequence of the first, of the circulatory system, resulting from an injury or occurring as one of the effects of an operation. Young children, the aged, and weak individuals suffer most from shock. Children, however, recover most readily from its effects. Excessive weakness of the heart's action is the predominating feature in shock. The symptoms of shock and excessive loss of blood combined, as they sometimes are, with the effects of over or prolonged anesthetization, make up a clinical picture of a patient critically ill from the effects of an operation.

If a patient is suffering from shock as the result of an injury, none but the most imperatively demanded operations, such, for instance, as that required for the arrest of hemorrhage, or for the relief of some condition on which the continuance of the shock depends, should be undertaken. If shock comes on in the course of an operation, the latter should be concluded as quickly as possible; in some instances it will be necessary to suspend it entirely.

When the patient once rallies from shock, the improvement is continuous, and in some instances rapid. The terms "delayed shock," "secondary shock," and "imperfect reaction from shock" are misleading, and relate to conditions arising independently of the original shock, such as concealed hemorrhage

(see page 89), rapidly developing and virulent septic infection, fat embolism, pulmonary edema, renal insufficiency, etc.

Shock may be quickly recovered from if no vital organ is seriously involved in the injury or operation, or if the source of the depression is not persistent and continuous, such, for instance, as the presence of a mangled limb with crushed nerve-trunks, etc. In fatal cases the temperature becomes subnormal and death takes place from combined cardiac and respiratory failure.

In the **prevention of shock** the patient's mental condition should be taken into account, and, as a part of the preparation for the operation, every encouragement given him as to its outcome. Nervous patients are benefited by a few days' preliminary rest in bed. Opiates and bromids may be given as indicated. A $\frac{1}{20}$-grain dose of strychnin may be given after anesthetization, if indicated. During the operation the patient should be kept warm, and, in long operations, artificial heat should be applied. Loss of blood must be avoided and operations brought to a close as quickly as possible.

The preliminary injection of cocain into a nerve-trunk of a part operated on inhibits the transmission of afferent and efferent impulses and tends to lessen operative shock (Crile).

Treatment of Shock.—The patient's head is to be lowered, and artificial heat applied to the whole body by means of hot-water bags, or, better still, the patient may be wrapped in blankets wrung out of hot water. An intravenous infusion of from 800 to 1200 c.c. of saline solution (1 dram of common table salt to a pint of sterilized water at 115° to 120° F.) should be given. Pending preparations for this, the saline solution is to be injected into the loose connective tissue behind the breasts (see Hypodermoclysis, page 352). High enemas consisting of a quart of hot saline solution, 3 ounces of black coffee, and 2 drams of whisky should be given. Strychnin should be administered carefully (not more than two $\frac{1}{20}$-grain doses). Oxygen is to be administered. Nitroglycerin and amyl nitrite are contraindicated in shock on account of the vasomotor dilatation which they induce. Ergot, on the other hand, is said to possess distinct value in this connection. I have employed it with apparent advantage. It is to be given hypodermically in the shape of either ergotol in 30-minim doses repeated every half hour, or solutions of the aqueous extract.

SPECIAL DANGERS OF OPERATIONS

These relate chiefly to the locality in which the operation is performed and its proximity to certain important nerve-trunks and large vessels. Prolonged operations on the intracranial contents, or in the area of important and extensively distributed sensory nerves, such, for instance, as the fifth or trifacial nerve, either by direct means or by reflex inhibitory effects, greatly augment the dangerous effects of shock.

The **entrance of air into veins,** though a rare circumstance, is an accident against which the surgeon should be on his guard, particularly when operating in the lateral region of the neck. In the event of a wound of a large vein in this locality the opening in the vessel is kept patent by the cervical fascia, while the vacuum produced by the inspiratory effort causes the air to rush in. The accident has occurred most frequently in connection with the internal and external jugular veins and the subclavian. It has happened,

however, in the case of the cerebral sinuses, and the facial, axillary, subscapular, thoracic, and femoral veins (for Air Embolism see page 98).

The **dangers of hemorrhage** are enhanced when the operation is conducted in the neighborhood of the large vessels. These dangers arise, not only from the risks of wounding the main trunk, but from the fact that wounded branches bleed more freely under these circumstances and a large amount of blood is lost in a short time.

Patients with **hemophilia** (**"bleeders"**) are the most unpromising of all subjects for operation. Scarcely anything has been brought to light concerning the pathology of the disease and almost as little success has attended efforts to cope with the bleeding which occurs in its victims. This may result from the most trivial injury and may be initiated by a diseased condition, such, for instance, as occurred in a patient under my care in the German Hospital, in whom the ruptured vessels at the site of a perforation of the vermiform appendix gave rise to a hemophilic bleeding, which all efforts, including exposure of the source of the hemorrhage and topical pressure, failed to arrest. In the treatment of hemorrhage in a hemophiliac where direct pressure can be made, this offers the best chance of arresting the bleeding. In addition, the common styptics, adrenalin chlorid solution (1 : 1000) by subcutaneous and intravenous injection, heat, cold, the actual cautery, the rectal administration of gelatin solutions (5 per cent), and the internal administration of chlorid of calcium and ergot should be tried.

POST-OPERATIVE COMPLICATIONS

The most important immediate post-operative complications are the following:

Excessive Retching.—This may become a source of anxiety on account of the possibility of cerebral hemorrhage due to the straining efforts in patients with atheromatous vessels. Lavage with saline solution is of service. It sometimes becomes necessary to administer a hypodermic injection of morphin to quiet the reflex disturbances.

Recurring hemorrhage from the slipping of a ligature, or from a vessel which was injured near the close of the operation and which failed of ligation, is an occasional complication at this stage (see Treatment of Hemorrhage, page 336).

More or less complete **suppression of urine** (**anuria**) and distention of the bladder from **retention of urine** are to be guarded against. Fluids given freely to drink, saline irrigation of the rectum, copious enemas of saline solution, dry cupping of the renal region to relieve the congestion of the kidneys on which the suppression depends, and, if this fails, wet cupping of the same, hypodermoclysis, and, finally, intravenous saline infusion, are the measures to be resorted to in cases of anuria; in cases of retention careful catheterization should be performed.

Acute Post-operative Dilatation of the Stomach.—This has been observed as the result of a more or less complete prolapse of the small intestine into the lesser pelvis. The pressure of the mesentery, particularly of the superior mesenteric artery, thus arising causes compression and obstruction

of the duodenum, with consequent dilatation of the latter and finally of the stomach as well. The predisposing causes are said to be the weakening effects of general anesthetization and too copious purgation preceding the operation. The condition can occur only with the patient in the dorsal position.

The **symptom** dominating the clinical picture of this post-operative complication is vomiting, which is often very abundant and persistent, and usually biliary; more rarely brownish-gray or blackish. Intractable constipation is usually present; flatus is generally obstructed; thirst is urgent; the pulse is increased in frequency; the temperature remains normal. The patient's appearance is that of one critically ill. The **diagnosis** is confirmed by the demonstrable presence of gastric dilatation.

The **treatment** consists in placing the patient in the abdominal position (flat on the abdomen) at once upon the appearance of symptoms of duodenal compression (Muller). Lavage may also be practised.

The more **remote complications** include delirium tremens, sepsis, peritonitis, tympanites, and pneumonia.

Delirium tremens is a form of mental disturbance in which muscular tremors are a characteristic feature. It occurs in persons habitually intemperate in the use of alcohol. It may follow an operation or any form of injury. The type of the disease is milder, as a rule, than that which develops without injury. The attack is sometimes preceded by restlessness and tremulousness, and is ushered in by insomnia and delusions of persecution and of the presence of reptiles, animals, and insects which inspire fear and horror. If the patient is not restrained, he will attempt to escape from these by flight, entirely insensible to the pain of an injury or of the part operated on. In some cases there is marked and rapid loss of strength. The attack may pass off suddenly after a long sleep. Death may take place from prostration or suddenly from heart failure.

The **treatment of delirium tremens** consists in warding off an impending attack by means of stimulants in small quantities, and the administration of capsicum and digitalis. Sleep should be secured by chloral hydrate and the bromids. During the attack the patient should be protected from doing himself harm by a restraint sheet and wristlets. Malt liquors should be given *ad libitum*. Opium should be reserved for cases in which restraint to the extent of preventing displacement of splints or dressings is difficult or impossible.

Septic inflammation is the most important of the post-operative sequels, and its advent should be most carefully watched for by a frequent inspection of the temperature record. If it occurs, its further progress should be guarded against by thorough disinfection of the wound, the sutures being removed for this purpose, if necessary (see page 58). In abdominal cases the surgeon will be on his guard particularly against the occurrence of peritonitis. Tympanitic distention is sometimes the cause of considerable discomfort and will require for its relief either the use of the rectal tube or enemas containing turpentin or lac asafetida.

Post=operative pneumonia may be the result of exposure of the patient while under the anesthetic, either when he is on the operating table or subsequently. It has likewise been attributed to the refrigerant action of the ether when this has been employed as the anesthetic agent. In the hypostatic form it arises from keeping the patient constantly in the dorsal decubitus. **Septic**

pneumonia results from the inspiration of septic agents during the anesthetization, and from the passage of septic material into the air-passages from the nasal, nasopharyngeal, and buccal cavities after operations in these regions. In the latter case it may be followed by gangrene of the lung. **Prophylaxis** consists in (1) employing due care not to expose the patient unnecessarily while under the anesthetic; (2) keeping the patient's head turned to one side during the anesthetization in order to favor the accumulation of mucus, etc., in one or the other of the lateral portions of the pharynx, whence it may be readily removed by a strip of gauze leading out of the corresponding corner of the mouth, or by sponging; (3) taking measures to establish and maintain aseptic conditions of the parts after operations on the mouth, throat, and nose (see page 49); (4) alternating the position of the patient during convalescence between the lateral and the dorsal.

The **treatment of post-operative pneumonia** embraces dry cupping, a pneumonia jacket (oiled silk lined with cotton batting), and systematic change of decubitus. Ten-grain doses of carbonate of ammonia in half an ounce of equal parts of mucilage of acacia, spearmint water, and syrup, given every two hours, alternated with 10-grain doses of chlorid of calcium, are of service. (For Gangrene of the Lung, see page 682.)

Causes of Death Following Surgical Operations.—Death following a surgical operation may arise from hemorrhage, from shock, or from these two combined; or from these with the addition of prolonged or too profound narcosis; or from entrance of air into the veins; or from overstimulation of the heart arising from the absorption of several doses of drugs at once administered hypodermically during shock. During and after anesthetization the foundation may be laid for a fatal post-operative pneumonia (*vide supra*). Suffocation arising from inspiration of vomited matters while the patient is still unconscious may prove fatal. Death may occur from acute dilatation of the stomach (*vide supra*). Uremia following anuria in those with diseased kidneys may destroy the patient. Infections from pus organisms may give rise to lethal pyemia and septicopyemia (see pages 182 and 184). The special infection of tetanus is quite uniformly fatal. **Delirium tremens** following a long debauch may be fatal. Death may be due to some organic disease of a vital organ; to pulmonary thrombosis; to extension of infection and complicating inflammations of newly involved tissues or organs; to perforative peritonitis resulting from rough handling of the intestines; to post-operative peritonitis due to imperfect asepsis; to intestinal obstruction caused by angulation at the site of adhesions following an abdominal section; or to senile asthenia aggravated by surgical interference in those both aged and infirm.

Acute cardiac dilatation may cause death in a totally unexpected manner, and at a period so remote from the operation as to arouse some doubt as to the connection between the two. In six cases occurring in my experience death took place at periods varying from ten to sixteen days after the operation. The latter had been succeeded by an absolutely uneventful course up to the occurrence of the acute dilatation. In none of the cases had a heart lesion been made out before the operation. In three of the cases the patients were awakened from sleep by the faint sensation which, in two of the cases, preceded death by less than a minute. It is estimated that in none of the six cases did the patient live longer than a minute after the first symptom. In those

attacks which occurred while the patient was awake the first impulse was to ask for a drink of water, but before this could be given the patient's alarming appearance attracted attention to the pulse, which was found to be weak and fluttering.*

* The following is a summary of the cases: one case of amputation of the shoulder-joint; death on the sixteenth day after operation and after complete healing; the patient was being conveyed home in a carriage when attacked. One case of abdominal hysterectomy; death on the eleventh day while the patient was uneventfully recovering from the operation. Two cases of appendectomy; death in the one case on the eleventh day and in the other on the fifteenth day. In the first case the patient died while on the bedpan; in the other case the patient was awakened from sleep by the faint, sinking sensation. One case of operation for radical cure of hernia; patient attacked on the fourteenth day in the night and had time only to whisper faintly a message for his family when he breathed his last. One case of nephrolithiasis which had gone on to the thirteenth day without the slightest deviation from the normal, after the recovery from the anesthetic; the patient asked the nurse for a glass of water in a faint whisper, and died before it could be handed to her. The youngest patient was thirty-two, the oldest was seventy. In all of the cases there was the predominating feature of an absolutely uncomplicated and apparently safely established convalescence up to less than two minutes before the patient's death. In the three cases in which autopsy was permitted the left ventricle was found somewhat thinner than the average normal ventricle; the heart's action had been arrested in ventricular diastole; the remaining portions of the organ, as well as all the other organs of the body, were found to be in a healthy state.

SECTION IX

SURGICAL ANESTHESIA

Surgical anesthesia is of two kinds, general and local. The first named is sometimes called **narcosis.**

For ordinary surgical purposes general anesthesia must be produced. The ideal production of general anesthesia without narcosis has yet to be reached.

The **indications** for the use of anesthetics are various. The susceptibility of the individual to pain, the length of time the proposed operation is to occupy, the amount of pain, the necessity for restraining the patient's movements during the operation, must all be taken into account. Some operations may be quite prolonged and yet comparatively free from pain; hence continuous and prolonged anesthesia is not required. Again, an operation may give rise to the most exquisite pain and yet be of such short duration as scarcely to justify the employment of a general anesthetic. Were it not for the fact that there is a lurking danger attendant on every occasion where an anesthetic is employed, anesthesia could be induced with propriety for all operations, including those causing even the slightest pain.

Surgical anesthesia is also induced for the purpose of producing relaxation of muscular structures, as, for instance, in the reduction of dislocations and for the adjustment of the displaced fragments in fractures. Finally, it is almost impossible to make a diagnosis in some cases without the aid of anesthesia.

The Physiologic Action of Ether and Chloroform.—The anesthesia obtained by the use of these agents results from the direct influence of the drug on the nervous system, as shown by Bernstein's experiments on frogs. The frogs were successfully chloroformed after the aorta had been severed, all blood withdrawn and its place supplied by sodium chlorid solution.

Further experiments by Bernstein demonstrated that portions of the central nervous system excluded from the circulation are not influenced by the anesthetic, as shown by the fact that under these circumstances the peripheral portions supplied by these centers do not lose their reflex irritability. In another experiment the femoral artery was ligated, after which it was found that both limbs alike were affected by the influence of the anesthetic.

Early in the administration of ether there is a cardiac and a vasomotor stimulation; later this is followed by depression and fall of blood-pressure.

The action of chloroform on the heart is as follows: it acts directly on the heart muscle, steadily and strongly depressing and paralyzing it or its contained ganglia; to this depression is due the early fall of blood-pressure occurring in chloroform narcosis.

While the pupil may become temporarily dilated slightly beyond the normal during the early stages, it becomes contracted below the normal as the anesthesia advances. A return to the normal requires that more of the anesthetic be administered, but a sudden dilatation imperatively demands its immediate withdrawal.

The Selection of an Anesthetic.—The anesthetic agents usually employed at the present day are nitrous oxid, ether, and chloroform. These should be obtained in as pure a state as possible. Tests are given for ascertaining their purity, but practically the surgeon is at the mercy of the manufacturer, and should therefore supply himself from one of standing and reputation.

Nitrous oxid is the safest general anesthetic at present known. In experienced hands its use is practically without risk. Any danger that may attend its use in unskilled hands is eliminated by administering it with oxygen. Under these circumstances the dangers are but infinitesimal. Unfortunately, nitrous oxid is both inconvenient and inapplicable for most surgical operations, though it may be employed for those of short duration.

Sulfuric Ether.—Of the anesthetic agents suitable for prolonged administration **ether** is the safest, and, unless directly contraindicated, should be invariably employed. Its great advantage is the stimulating effect which it produces on the circulation. Even the sitting posture is not liable to result in circulatory respiratory depression while the patient is under its influence. It should therefore be the routine anesthetic for general surgical work.

The **contraindications** for the use of ether are *extreme emphysema, chronic bronchitis* with *expectoration and dyspnea,* and *advanced pulmonary phthisis.* In the case of *very old persons* and in those *extremely obese,* as well as in *very young children,* ether is not generally employed. It may, however, be employed in old persons in whom the arteries are not markedly atheromatous, and in young children, and even in infants. In the case of the latter, however, the open method should be used. Though albuminuria, nephritis, and uremia have been known to follow the use of ether, it is now generally believed that these sequels may follow, although perhaps not so frequently, when chloroform is administered in equal amounts, and that they do not follow either anesthetic as frequently as is generally supposed unless renal disease exists beforehand. It may be observed, however, that the kidneys play a large part in the elimination of the anesthetic agent, and if diseased, may fail to perform their function, or become congested through the necessarily increased activity of the vessels, suppression following.

Chloroform is used in operations on the palate, tongue, jaws, mouth, nasal cavities, nasopharynx and pharynx, on account of the difficulties arising from attempts to anesthetize the patient with ether mingled with a large amount of air. When the actual cautery is to be used in these regions, even when ether might otherwise be employed, chloroform must be substituted, on account of the inflammability of the vapor of the former. Under all circumstances, however, unless the use of ether is strongly contraindicated, anesthetization by this agent should be first obtained and chloroform employed only during the actual performance of the operation.

In cases in which there is a fixed condition of the abdominal walls, as, for instance, in connection with general peritonitis from perforation, and intestinal obstruction with respiratory difficulty, chloroform may be used preliminarily to etherization.

Finally, when it is shown by actual trial that ether is badly borne, either through uncontrollable coughing, embarrassed breathing, deep cyanosis, or prolonged tonic spasm, chloroform may be temporarily substituted. When the patient is fully anesthetized by chloroform, however, it will frequently be

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found that these conditions have disappeared and that ether may be administered. In stenosis of the larynx and trachea chloroform may be employed with advantage, as it is less likely to irritate and produce spasm of the glottis.

The Preparation of the Patient for an Anesthetic.—It not infrequently occurs that the condition of the patient is such as to prohibit the employment of an anesthetic. Each organ should be carefully examined beforehand, as far as possible, but particular attention should be paid to the heart and vessels, lungs and kidneys. The digestive organs should not be overlooked. The intestinal canal should be emptied by a purge administered the day previous, and thereafter only food allowed which shall leave the minimum amount of residuum in the bowels. Meat broths and such food fulfil this indication. No liquid food is to be permitted for at least four hours before the operation, and solid food should be omitted, wherever practicable, for eight hours previous. If this rule has been transgressed, in emergency cases where food has been recently taken, lavage may be practised. The **reasons for withholding food** are (1) the presence of food is provocative of vomiting, with resulting dangers of inspiration of vomited food; (2) excretion of ether takes place by the gastric and intestinal mucous membrane, and arrest of digestion and the production and absorption of toxic products occurs in consequence.

Except in emergencies, the **examination of the heart and lungs** should be made on the previous day. The patient is thereby made more comfortable by the assurance that these are in a healthy condition. This likewise gives the surgeon an opportunity to postpone the operation, in case these organs are not found normal, without unduly exciting the fears of the patient. This examination should be made, if possible, by the person who is to administer the anesthetic. In emergency cases the examination may be made just before commencing the administration of the anesthetic.

The **examination of the kidneys** is most important. Not only should the presence or absence of albumin in the urine be determined, but tube casts should be eliminated as well. The examination of the urine for urea is, however, of far more importance than the test for albumin or even a microscopic examination for casts. It is now well known, in cases of renal disease, that the appearance of both albumin and casts may be, and often is, intermittent. The crucial test of the sufficiency of the kidneys is the amount of urea that they eliminate. Under ordinary circumstances a healthy man should excrete in twenty-four hours from 240 to 420 grains of urea, a woman somewhat less. No one can safely be given a general anesthetic when the total urea falls below 100 grains, and a total quantity of 200 grains should put the surgeon on his guard. The total quantity passed in twenty-four hours should also be ascertained, the specific gravity learned, and on the basis of this, an estimate of the daily excretion of urea made. A ready method of ascertaining the total amount of urea in twenty-four hours, which is approximately correct, is as follows: Multiply the fluid ounces passed in twenty-four hours by the last two figures as expressed in the specific gravity; this gives the total amount of solids in *grains*. Divide the result by 2, and this will give the amount of urea in grains. Example: Total quantity 50 oz., sp. gr. 1018; $18 \times 50 = 900 \div 2 = 450$ (Bartley). In fact, the necessities of a life insurance examination are insignificant as compared with the demands of a properly conducted inquiry before administering an anesthetic.

Just before the commencement of the anesthetic the administrator should examine the patient's mouth for false teeth or other objects which may become displaced and obstruct respiration. The nose and throat may be cleansed with advantage with a warm normal salt solution. In debilitated patients the preliminary administration of an enema consisting of half a pint of saline solution with two ounces of brandy is of service.

Effects of Ether.—These are usually divided into four stages. In the **first stage,** if the patient experiences suddenly the irritating properties of the vapor, there will be closure of the glottis, repeated acts of swallowing, cough, and a sense of suffocation. There are certain sensory disturbances, such as flashes of light and exaggeration of sounds; singing in the ears and hammering noises are experienced; pricking sensations may be felt throughout the body. The pulse is accelerated and the pupils are large and mobile.

Loss of consciousness marks the commencement of the **second stage.** Just as this condition supervenes, however, in some cases, a period of excitement occurs, in which the patient may shout, sing, or make vigorous struggling efforts with the arms and legs. When these are only slight, they should not be restrained. Tonic convulsive movements are observed in some cases; in others the muscular contractions are clonic. Tremors may be present (ether tremor). Mucus and saliva are sometimes freely secreted. The pupils are mobile and somewhat dilated. The pulse is full and bounding. The features are flushed and the conjunctivae injected. The breathing is often irregular and sometimes restrained or even suspended. The latter may be corrected by permitting the patient to breathe a little air. As the respirations become more and more regular the muscles acting on the jaw, as well as those of the larynx, which are sometimes thrown into a state of spasm, become relaxed and slight stertor is present.

In the **third stage** the respirations become regular and stertorous, the extremities flaccid, and the cornea insensitive. The respiratory efforts are increased in frequency and are forcible and distinctly audible, particularly if mucus is present in the fauces and larynx. Masseteric spasm occurs now and again, necessitating the pushing of the jaw forward. This, with irregularities in breathing, indicates that the patient is passing back into the second stage. The pulse is slower than in the second stage but is still more rapid than normal. The pupils are of moderate size or slightly dilated. Both eyeballs may be fixed in the horizontal plane or both may slowly move. There may be loss of associated movements, one eyeball being fixed while the other slowly moves (Warner).

The **fourth stage** of etherization is the stage of danger, and should never be reached. In it respiratory failure occurs; the pupils become more dilated; pallor gives place to a dusky hue of the surface; the eyelids are slightly separated; the pulse becomes less forcible and sometimes slower.

With the occurrence of respiratory failure the stertor first ceases and then the breathing efforts become less and less forcible, shallow, and slower; in some cases the breathing is jerky, intermittent, and gasping.

If one or more of the phenomena above described occur in connection with a sensitive conjunctiva, they are due to causes other than an overdose of ether.

The invariable rule should be to watch the patient carefully, both during and after the anesthesia.

Methods of Administering Ether.—Two systems of administering ether are recognized, viz., the open and the close. When the open system is employed, a plentiful supply of air is allowed with the ether. In the close system the supply of air is restricted, the patient breathing to and fro into a rubber bag or other ether device attached to the face-piece of the inhaler.

Open System of Administration.—While ether may be administered by means of an improvised inhaler cone consisting of a towel and newspaper folded together and fashioned into proper shape, with a sponge or bundle of gauze forced into the opening left at the apex of the cone, yet it is desirable to furnish as large an evaporating surface as possible, and at the same time permit the free ingress and egress of air. This may be accomplished by Allis's inhaler (Fig. 59). The apparatus is to be placed over the face and the patient told to breathe deeply, in order to gain his confidence. The ether is then to be dropped on the inhaler in a steady succession of drops scattered over the margins of the evaporating surface of the inhaler. As the effects of the anes-

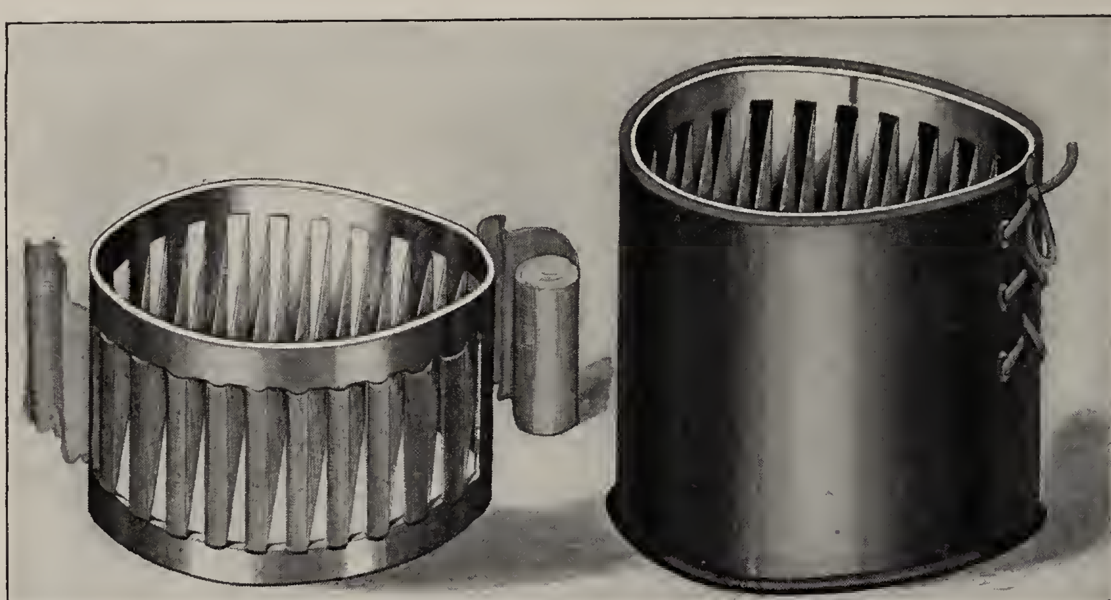

Fig. 59. Fig. 60.
FIGS. 59 AND 60.—ALLIS'S ETHER INHALER.
Showing fenestrated metallic frame with a muslin roller in course of application, and the inhaler complete with cover.

thetic become manifest, the entire area is moistened, after which the ether is allowed to run in a small stream until the muslin material of the inhaler becomes well saturated, in which condition it is to be maintained until the patient is thoroughly anesthetized. This method of gradually increasing the strength of the ether vapor prevents the feeling of suffocation commonly experienced when some of the other forms of inhaler are used, and permits the larynx to become accustomed to the vapor, whereby the respiratory rhythm is but little, if at all, interfered with.

The administration should be rapidly pushed as the patient becomes semi-unconscious, it being borne in mind that at every free and deep inspiration almost the entire bulk of ether is removed from the inhaler. It is therefore incumbent on the administrator to keep up, without intermission, a constant supply of ether to the inhaler, every portion of the evaporating surface being kept equally moist, until the patient is completely under its influence. In this

manner the minimum amount of ether is used, and the patient anesthetized in from three to five minutes. The stage of excitement is very much shortened and may not occur at all.

The objections urged against the open system by some surgeons are (1) the larger quantities of ether needed to secure and maintain anesthesia; (2) the difficulty of anesthetizing alcoholic subjects; (3) the waste of ether and the presence of the vapor in the room; (4) the more prolonged stage of excitement when present; (5) the greater risks of bronchial and pulmonary affections.

Close System of Administration.—This system is largely used abroad, particularly in Great Britain. In Clover's inhaler (Fig. 61) the face-piece fits the face accurately and the patient breathes backward and forward into the attached rubber bag, the ether being contained in a spheric-shaped reservoir placed in the body of the instrument. This

Fig. 61.—Clover's Ether Inhaler.

reservoir is surrounded by water to prevent the apparatus from becoming too cold. There are no valves and no provision for the ingress of fresh air. The apparatus is fitted closely to the face and the rubber bag attached while the patient is making an expiratory movement. This fills the rubber bag with expired air, which the patient breathes for half a minute before the ether vapor is turned on. No fresh air is permitted until signs of cyanosis appear, associated with stertorous breathing, or there is impairment of respiration or circulation. When it is necessary to admit fresh air, the inhaler is removed for two or three breaths. When full surgical anesthesia is established, the minimum amount of ether vapor is permitted to pass to the face-piece, and air is admitted in sufficient quantities to prevent cyanosis. The object of the administration is to give as little air as possible short of producing actual cyanosis. The less air given, the less ether will be required. The more air the patient is permitted to breathe, the more ether will be required to maintain surgical anesthesia.

Ormsby's inhaler, as improved by Hewitt, has an arrangement to permit the giving of air with the ether vapor in varying proportions; or either all air or all ether may be inhaled. The ether is poured on a sponge, the metal compartments containing it being fitted with a removable water chamber to prevent the sponge from becoming too cold (Fig. 62). In using Ormsby's inhaler the sponge is first wrung out of warm water, the water chamber removed and immersed in hot water for a few minutes, and then replaced. Half an ounce of ether is poured on the sponge, and, with the air-stop open, the inhaler is gradually brought toward the patient's face. The patient is encouraged to breathe deeply.

Clover's inhaler is undoubtedly the best of the close inhalers for inducing anesthesia, while Ormsby's has some advantages over Clover's in maintaining the anesthetic effect. The latter, however, is more economic in respect to ether. The use of Ormsby's inhaler is attended by more struggling while the patient is being anesthetized, but is well adapted for administering ether after precedent anesthesia by nitrous oxid.

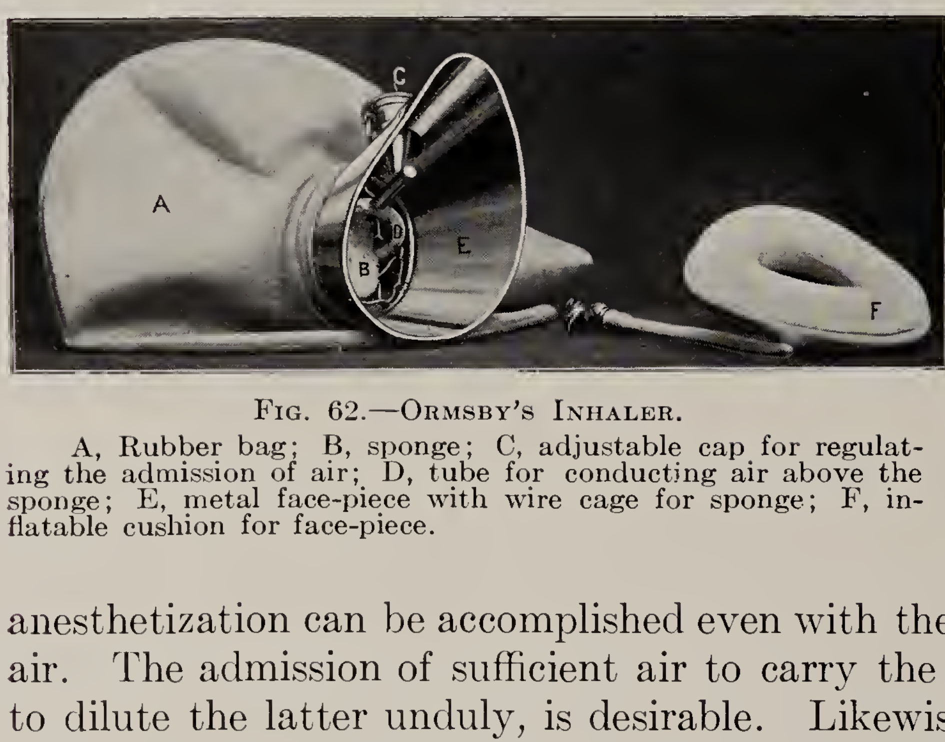

Fig. 62.—Ormsby's Inhaler.

A, Rubber bag; B, sponge; C, adjustable cap for regulating the admission of air; D, tube for conducting air above the sponge; E, metal face-piece with wire cage for sponge; F, inflatable cushion for face-piece.

The Semi-close System.—This is a compromise between the open method, with its waste of ether and difficulty of anesthetizing alcoholic and vigorous subjects, and the close method, with its complicated apparatus and asphyxial tendencies. The success of the open method shows that anesthetization can be accomplished even with the constant free access of fresh air. The admission of sufficient air to carry the ether vapor, yet not enough to dilute the latter unduly, is desirable. Likewise, it is of advantage both in the saving of ether and in the keeping of the evaporating surface warm, to find some means whereby the full force of each expiration is not exerted to drive the expired air, with a certain amount of ether vapor, directly from the inhaler into the room. In accomplishing this, the retention of the expired air in the inhaler for a time is necessary, but the evils of this are minimized by the constant accession of fresh air which is mingled with the previously expired air as it is reinhaled.

An inhaler devised with the above objects in view (Fig. 63, A) consists of a flattened cylinder of metal, with one end closed. An opening on each side near the closed end serves for feeding the ether on the evaporating surface. The latter consists of upholsterer's curled hair. The openings likewise serve the purpose of admitting sufficient air to reinforce the expired air to a sufficient extent. The size of these openings may be regulated as required. Two metal gutters are placed on the inside of the inhaler to catch whatever superfluous ether may be poured into the inhaler and lead it to a small vent hole as a telltale on each side of the inhaler.

While using this inhaler the patient's head is turned to one side, in order to permit the mucus and saliva to accumulate in the lateral portion of the pharynx,

and the passage of these through the glottic opening, with the attendant risks of inhalation pneumonia, is thus avoided. The patient breathes through the inhaler for a minute. This serves to impart confidence and at the same time warms the inhaler. Ether is then placed in small quantities on the evaporating surface through the slot which is uppermost, the quantity being gradually increased as the second stage is reached, until finally a small stream keeps the evaporating surface thoroughly charged with the anesthetic agent. This is continued until the patient reaches the third stage, or that of surgical anesthesia.

The curled hair possesses advantages over the sponge, cotton, and gauze materials usually employed, in that its meshes do not become easily clogged and hence comparatively impermeable. It is likewise easily sterilized by boiling in water and may be used over and over again.

Method of Administering Chloroform.—Here also a special apparatus is advantageous, though the agent may be administered by means of

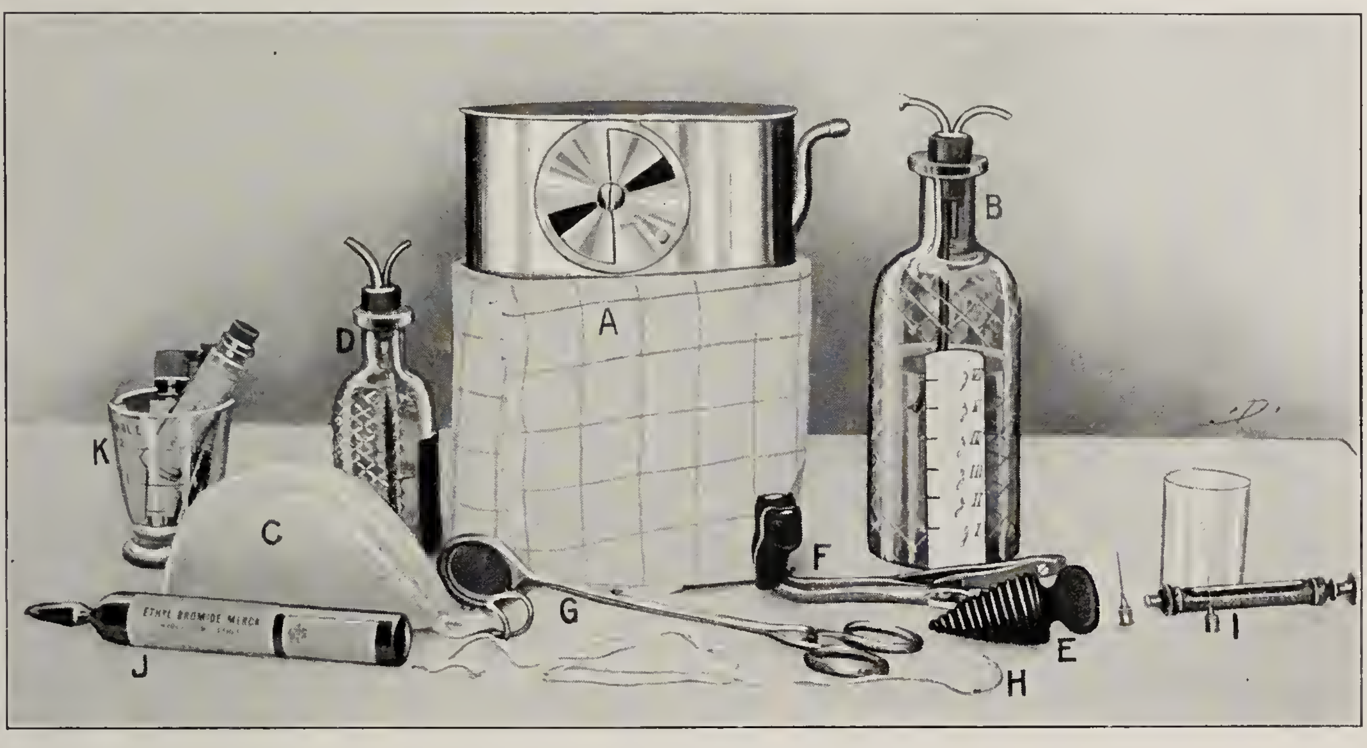

Fig. 63.—Anesthetizing Outfit.

A, Semiclose ether inhaler; B, dropper bottle for ether; C, Esmarch chloroform mask; D, dropper bottle for chloroform; E, screw-gag; F, lever-gag; G, tongue-forceps; H, needle threaded with silk suture for securing the tongue; I, hypodermic syringe and medicine glass; J, ethyl-bromid tube; K, measuring glass and hypodermic tablets.

a folded napkin or handkerchief. The mask of Esmarch, consisting of a wire frame, shaped to fit the face, covered with a merino material, is the best devised (Fig. 63, C). A modification of this by Schimmelbusch permits the ready change of the woven material used as an evaporating surface and also presents the advantage of being capable of being folded. As in ether, the administration of chloroform should be begun by placing the mask over the face and bidding the patient breathe deeply a few times. Then only a drop or two should be placed on the apparatus by means of the dropper bottle (Fig. 63, D), the stopcock of which should be graduated so as to permit slow dropping only. Each part of the mask should receive a drop of the chloroform in turn, the anesthetizer thus keeping up a constant supply. Chloroform should always be kept in a well-stoppered dark bottle, in order to exclude the white rays of light, under the influence of which it is decomposed into hydrochloric acid, chlorin, free formic acid, etc.

The position of the patient should always be the recumbent one in chloroform narcosis, with the head lowered; it is even recommended that the body should be placed at an angle of 45 degrees, the head depending.

The preliminary hypodermic injection of morphin (Nussbaum) is recommended, in order to lessen the amount of chloroform or ether required. As a stimulant to the respiratory centers atropin is also recommended to be given hypodermically. The preliminary hypodermic injection of spartein and morphin as a cardiac tonic is recommended (Langlois; Maurange). The anesthetizer should not permit his attention to be diverted while carefully watching the patient's condition. He should constantly keep his finger on the temporal or facial artery, carefully watch the patient's breathing and the corneal and pupillary reflexes, as well as the color of the skin.

Special Dangers from Ether Narcosis.—The dangers from ether inhalation are mainly those arising from asphyxia, and not, as a rule, from heart failure, though the latter may occur. For this reason, though the heart is not to be neglected, the greatest watchfulness is to be kept over the respirations. Usually there is some warning of danger during ether narcosis, symp-

FIG. 64.—JUNKER'S INHALER ARRANGED FOR ADMINISTERING CHLOROFORM THROUGH THE NOSE. A safety-pin is passed across the nasal tube to prevent the latter from slipping too far in.

toms of asphyxia coming on gradually. The first appearance of these should be met promptly by withdrawing the ether, and permitting the patient to breathe air for a while until the cyanosis ceases. The operator may note the dark color of the blood in the operation wound and notify the anesthetizer of the fact. In case of weak or failing respirations, artificial respiration should be resorted to (Sylvester's, see page 300). In case of coincident cardiac failure the method of stimulating the heart recommended in Chloroform Narcosis should be resorted to (see page 298).

The After-effects of Ether.—The most common immediate after-effects of ether are nausea, retching, and vomiting. These are far less likely to occur if the patient's stomach is entirely empty at the time of the administration. This, together with the use of the purest ether, reduces these symptoms to a minimum. Sometimes the nausea and vomiting come on just as the patient is recovering consciousness. More commonly, however, they take place while he is unconscious. These symptoms are rarely the cause of anxiety to the surgeon.

Bronchitis, pulmonary edema, and pneumonia occasionally occur after etherization (see page 285). When they take place, it is not always clear that

the ether is to be held responsible. Their occurrence is to be provided against, however, by a proper examination of the chest organs, and by a postponement of the operation, whenever possible, in those suffering from bronchial catarrh or other abnormal conditions of the respiratory organs. Other precautionary measures are (1) keeping the patient's head turned well to one side during the administration in order to avoid inhalation of mucus and saliva; (2) avoiding all unnecessary exposure to wet coverings, drafts, etc., while the patient is on the operating table and after he has been removed to his room.

Ether has been accused of causing **albuminuria, nephritis, and uremia.** It is now believed that these conditions rarely occur except in cases in which they have been present beforehand. **Mental disturbances, choreiform movements, hemiplegia** from cerebral hemorrhage, and **jaundice** are likewise to be mentioned as rare sequences of the use of ether.

The Effects of Chloroform.—The phenomena of chloroform anesthesia are very similar to those of ether. During the **first stage,** however, the sense of suffocation, swallowing, coughing, and holding the breath are, as a rule, absent. This is owing to the fact that the vapor of chloroform is more pleasant to inhale than that of ether.

During the **second stage** mental excitement and struggling are somewhat less common than when ether is administered, particularly where the open method of administering the latter is employed by those unaccustomed to its use. In muscular and alcoholic male subjects, as well as in hysteric and excitable women, there is more or less rigidity, with attempts to rise to the sitting position, incoherent gesticulations, etc. Tonic spasm and irregular breathing may occur in some subjects in this stage; these pass away, however, and the advent of regular respirations, with slight snoring, marks the third stage of anesthesia.

In the commencement of the second stage the pulse is accelerated, but as the third stage is approached it becomes normal. The pupils are, as a rule, mobile and more or less dilated, and react sluggishly, if at all, to light. As the anesthesia deepens they tend to become smaller and more fixed.

The Third Stage.—As in the case of ether, the third stage of the effects of chloroform marks the presence of surgical anesthesia. The respirations, however, are more quiet, though in plethoric, flabby, and obese subjects there may be more or less stertor, and some rigidity of the jaw muscles. Except in this class of cases it is not necessary, as a rule, to keep the jaw pushed forward in order to maintain free respiration. Indeed, at times the breathing may be so quiet under chloroform as to awaken anxiety.

The circulation is more sluggish under chloroform than under ether. In the third stage the pulse may become even slower than the normal. In some cases in which it was comparatively feeble in the first and second stages it is found to grow stronger in the third stage.

The behavior of the eye reflexes is almost identical with that under ether anesthesia. The pupil is moderately contracted and averages somewhat smaller than in etherization. The pupil is an important guide in the administration. When it is very small, the patient is not well under the chloroform, and when it is somewhat dilated either the anesthesia is dangerously deep, or the dilatation is of reflex origin and is associated with a light anesthesia. The

lid reflex is abolished and continues so as long as the patient remains in the third stage.

The **muscular system** is completely relaxed under full chloroform anesthesia. The **color of the face** is at first heightened; afterward there is a tendency for it to become paler than the normal, particularly when the patient is coming out from the anesthetic and when vomiting is about to occur. The temperature is always reduced.

Special Dangers from Chloroform Narcosis.—The majority of fatalities in chloroform narcosis occur early in the administration, *i. e.*, in the second stage and at the commencement of the third, and in **muscular** and **alcoholic subjects,** as well as in **hysteric** and **excitable** patients.

Evidence of great mental excitement, when present, indicates caution in the administration. This, together with irregular and shallow breathing, is to be met by a plentiful dilution of the chloroform vapor with air. Prolonged tonic spasm is a particularly dangerous feature. The general contraction of all the muscles of the body forces the venous blood to the right heart, from which it is prevented from escaping by the embarrassment of the pulmonary circulation incident to the want of fresh air. The right heart, being incapable of emptying itself, is unable to contract and becomes distended; unless the conditions are quickly relieved the patient dies from **acute cardiac dilatation.** The administration must be suspended and the patient made to breathe by forcible and intermittent pressure on the base of the thorax, or, if necessary, by artificial respiration. Aid in "breaking" the spasm of the respiratory muscles is sometimes afforded by forcibly dilating the sphincter ani.

Clónic movements affecting the arms, whereby the latter are jerked more or less rhythmically toward the median line of the body, are due to spasm of the pectoral muscles. These should be regarded as strongly indicating the necessity for air (Hewitt).

Cardiac failure may result from an overdose of chloroform, or it may occur quite independently of this, as shown by the fact that sudden syncope arises, in some instances, at the commencement of the inhalation, due in a measure **to excessive fright** and **apprehension.** Such sudden deaths occurring at the commencement of the operation were not unknown prior to the introduction of anesthetics. The freedom of ether, as well as of nitrous oxid narcosis from these fatalities is due to the fact that ether stimulates the heart and thus counteracts the depressing effects of the mental emotion, and nitrous oxid serves to overcome fear by quickly abolishing consciousness.

Fatal syncope may arise in connection with vomiting, or efforts at vomiting, due to faulty or too sparing administration. The presence of undigested food is specially liable to lead to this complication.

Asphyxial complications leading to acute cardiac dilatation have been already alluded to (*vide supra*). Many of the cases of death under chloroform attributed to pure cardiac failure are probably due to a feeble, fatty, or dilated heart, the action of which is still further hampered by minor degrees of respiratory embarrassment.

Treatment of Dangerous Chloroform Narcosis.—The supervention of dangerous symptoms in chloroform narcosis must be met by withdrawing the anesthetic, lowering the head, elevating the lower extremities, drawing

the tongue forward, and making artificial respiration. The Sylvester method is the preferable one. The dashing of hot and cold water alternately on the chest and abdomen is recommended by some, but is of doubtful utility. The same may be said of hypodermic injections of the various drugs recommended. These cannot be absorbed while the circulation is enfeebled, and there is danger that their repeated administration may lead to the absorption of an overdose when the heart's action is restored by other measures. This should be borne in mind when such powerful alkaloids as strychnin, cocain, digitalin, and atropin are used. The following points should be considered when these drugs are employed in dangerous chloroform narcosis: (1) Strychnin is a most powerful stimulant to both the heart and the respiratory centers. To be efficient it must be given in large doses in watery solution, from $\frac{1}{20}$ to $\frac{1}{10}$ of a grain being required in the case of an adult. Its effect on the respiration is first observed; that on the heart occurs more gradually. (2) Cocain is a stimulant to the respiration and may be given advantageously in combination with strychnin. These alkaloids given conjointly exercise a more powerful influence than either given separately (Wood). From half a grain to a grain may be administered in an emergency. (3) Digitalis is indicated preliminarily for those with a weak heart, and it may also be given in cardiac failure under the anesthetic. (4) Atropin is a useful stimulant to the respirations alone. Its use is more frequently indicated in ether than in chloroform narcosis. From $\frac{1}{50}$ to $\frac{1}{100}$ of a grain is the dose. These drugs may be given hypodermically, though their effect will not be apparent unless the circulation is reestablished. For this reason their administration should not be repeated frequently nor at too short intervals, lest the patient be overwhelmed by the final absorption of an accumulated dose.

Fig. 65.—Sylvester's Method of Artificial Respiration (Expiration).

While these drugs are being prepared and administered, a heated compress or a hot-water bag should be placed over the pericardial region. At the same time the diaphragm may be stimulated to contraction through the phrenic nerve by placing one pole of a faradic battery in the epigastric region and the other at the outer border of the sternomastoid muscle at its lowermost portion. This should not take the place of the work of making artificial respiration nor be permitted to interfere with it.

Artificial Respiration.—This is employed more frequently for the restoration of patients suffering from dangerous surgical narcosis than in any other connection. It should be commenced as soon as respiration actually ceases, as shown by the absence of all thoracic and abdominal movements, the absence of evidences of air passing from the mouth or nose, and the signs of deepening cyanosis.

Sylvester's Method.—The head and neck should be fully extended, the former hanging over the end of the table; the tongue is well drawn forward to prevent possible obstruction to the entrance of air. The arms are grasped at the elbows and pressed firmly for about two seconds against the sides of the chest (Fig. 65). If this does not cause an expiration, the pressure should be made below the costal margins in the direction of the diaphragm. The arms are now brought upward to each side of the head, inspiration being effected by thus increasing the capacity of the chest through the action of the pectoral muscles on the upper ribs (Fig. 66). These movements are kept up at the rate of about fifteen times a minute. With the occurrence of spontaneous efforts at breathing, care must be taken to supplement rather than substitute the normal respiration. The artificial movements are occasionally suspended in order to judge of the efficiency of the normal efforts.

Fig. 66.—Sylvester's Method of Artificial Respiration (Inspiration).

Laborde's method of rhythmic traction of the tongue is sometimes successful in restoring the respiratory reflex. The tongue is grasped by forceps and alternate traction and relaxation made about twenty times a minute. This is kept up for at least half an hour, unless respiration is established in the meanwhile. This method may be employed alone or in conjunction with other methods.

Intralaryngeal insufflation consists in forcing air from a bellows into the lungs through an intubation attachment (Fell-O'Dwyer method). Provision is made for the escape of the expired air through a branch tube. A modification of this apparatus consists of the substitution of a graduated pump for the bellows, and the addition of a mercurial manometer and automatic cut-off for preventing the backward leakage of air. This improved apparatus is also arranged for administering oxygen or an anesthetic while artificial respiration is being carried on (Matas).

Primary Anesthesia.—It has been suggested that advantage may be taken of a period of rather complete anesthesia which is said to intervene between the commencement of the administration and the occurrence of the stage of excitement. The patient is requested to hold up his arm and maintain it in that position as long as he possibly can. When it is no longer voluntarily held, a very short operation, such as an incision for an abscess lasting for not more than ten seconds, may be performed. It is not always possible positively to identify this stage, if, indeed,it is of constant occurrence. On the other hand, some surgeons assert that there are certain dangers, particularly those resulting from sudden shock, which arise from the attempt to proceed with an operation of any kind before the patient is fully anesthetized. Many European surgeons, however, prefer to operate as soon as the stage of excitement is over and before complete relaxation is established.

Precedent Anesthesia.—The use of anesthetic agents which produce rapid yet transient anesthesia has been advocated for the purpose of abolishing the stage of excitement incident to the employment of ether, as well as of lessening the length of time occupied in producing anesthesia, and hence the amount of ether used. The agent of this class in most common use is nitrous oxid, or laughing gas. Chlorid of ethyl and bromid of ethyl have also been employed. Nitrous oxid possesses the advantage of not inducing a stage of excitement; the agent itself is practically without taste or smell and is absolutely nonirritating to the respiratory tract; hence its administration excites no resistance on the part of the patient. The necessary apparatus, however, is somewhat bulky and complicated. Nevertheless, there can be no question that in experienced hands the use of nitrous oxid precedent to ether has great advantages, in selected cases, over the employment of ether in the usual manner.

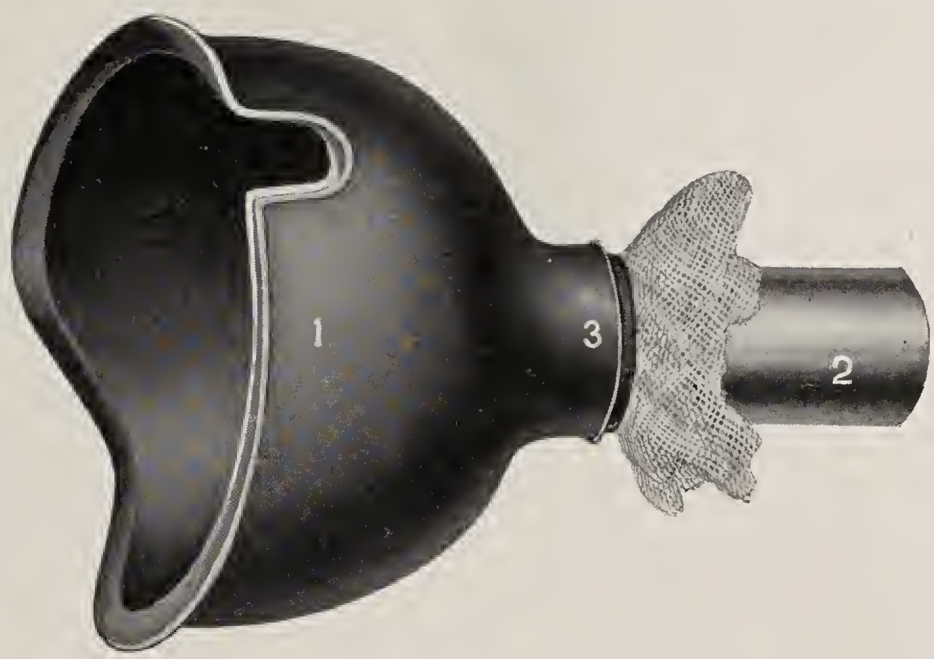

Fig. 67.—Ware's Apparatus for the Open Administration of Ethyl Chlorid.

1, Funnel-shaped rubber face-piece; 2, tube over the end of which two layers of gauze are stretched; 3, neck of the face-piece into which the end of the tube with its gauze covering is forced.

Chlorid of ethyl (Tuttle) and bromid of ethyl (Fowler) are equally efficient, and less expensive as to the cost of both the agent and the necessary apparatus. The absence of excitement cannot always be assured, and the odor, particularly in the case of bromid of ethyl, induces repugnance, and hence, in some instances, resistance to its use. In order to obtain the best results from chlorid of ethyl it is necessary to use a special inhaler, the agent being sprayed on the inhaler until the effect is obtained. In the case of bromid of ethyl the amount necessary to induce anesthesia, from three to four drams for an adult, is placed on a closed ether inhaler, and, all air being excluded, the patient inhales this for about one minute, or until the pupils are widely dilated or

the usual signs of surgical anesthesia are present. Sulfuric ether is then substituted for the bromid of ethyl.

Anesthesia by Means of Nitrous Oxid.—This agent is largely employed by dentists in tooth extraction. Its use is usually restricted to operations of short duration, though it has been employed in operations of an hour or more in length. It requires special skill in its administration and a special and somewhat complicated apparatus as well. For painful redressings, when the patient dreads them, and when ether or chloroform cannot be repeatedly used for passing urethral sounds, etc., it has been employed with advantage. It enters the blood by diffusion through the thin walls of the

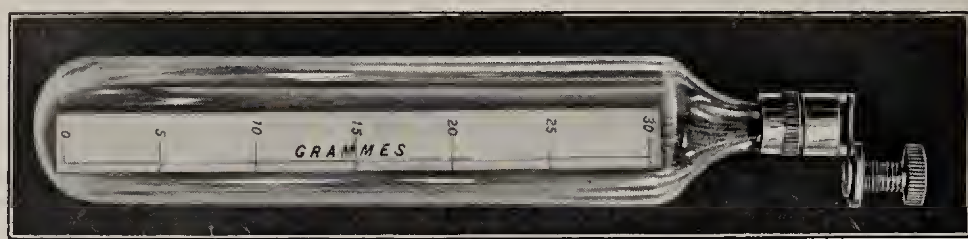

Fig. 68.—Ethyl Chlorid Tube.

alveoli of the lungs. While its anesthetic properties are manifesting themselves, the patient's respirations become labored and stertorous and finally very shallow. A cyanotic hue spreads over the surface, and it is not until this occurs that complete anesthesia is established. The latter lasts but a moment or two after the agent is withdrawn, which must be done before respiration ceases altogether, else the danger-line is reached.

Paul Bert (1875), by mixing together 80 volumes of nitrous oxid and 20 of oxygen, succeeded in obtaining an anesthetic agent the great advantage of which consists in the fact that all the reflexes necessary to life are present, while complete anesthesia is established, the normal condition returning as soon as the inhalation is suspended. The general introduction of this mixture is very much embarrassed by the complicated and cumbersome apparatus necessary for its use.

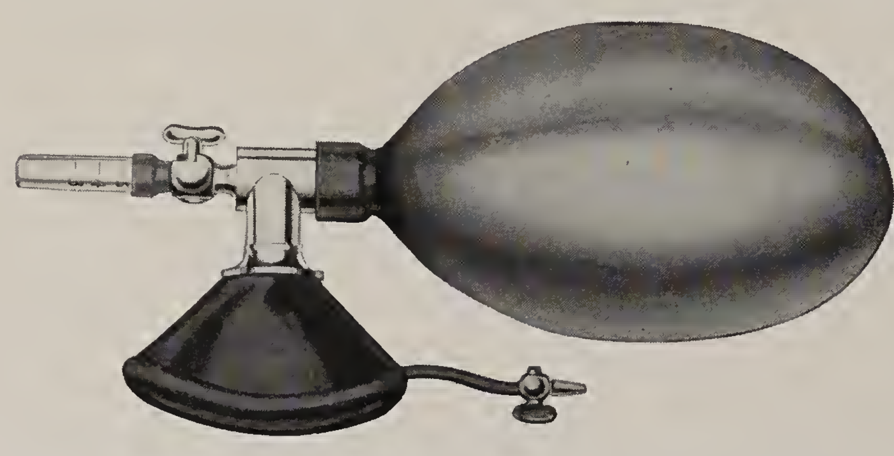

Fig. 69.—Daniels's Modification of the Clover Ether Inhaler, for Ethyl Chlorid Administration.

Ethyl Chlorid as a General Anesthetic.—The employment of this agent for the purpose of general anesthesia is indicated in minor operations of short duration. It may be administered with the patient either in the horizontal or in the sitting position. It is said that, with the exception of nitrous oxid, it is the least dangerous of general anesthetics, and that neither cardiac, respiratory or renal affections, nor pregnancy contraindicates its use. It may be administered to old and young alike. It is pleasant in its effects and rapid in its action.

Anesthesia is preceded by an analgesic stage, lasting for a fraction of a minute; this is followed by tonic contractures, increased frequency of the respirations, and moderate dilatation of the pupils. Short operations may be performed in this stage. The third stage, or that of profound anesthesia, is

reached in from a quarter of a minute to a minute later, according to the age of the patient and the method employed. In full anesthesia the muscles are relaxed; the respirations are deep and regular, with snoring in some cases; the conjunctival reflex is abolished and the pupils somewhat dilated. From 1 to 5 c.c. of ethyl chlorid are necessary to produce the third stage; 1 c.c. given about every minute thereafter suffices to maintain the anesthetic effect.

Either the close or the open method may be employed, preferably the latter by those not accustomed to its use. Ware's apparatus is the simplest (Fig. 67) for open administration; the ethyl chlorid is sprayed on the gauze from the ethyl chlorid tube (Fig. 68) as required. For the close method Daniels's modification of the Clover portable ether inhaler is useful (Fig. 69). The ethyl chlorid is placed in the graduated glass vial, and the latter connected with the tube and stopcock of the nitrous oxid attachment of the apparatus by means of a piece of red rubber tubing. The flow of ethyl chlorid is regulated by the stopcock.

Only a pure article should be employed. The preparation known as "kelene," the ethyl chlorid of Bengué, or that of Henning, of Berlin, may be used.

Disturbances of the Normal Course of Anesthesia.—The disturbances of the normal course of anesthesia may be divided into those which occur during the period of excitement and those which occur during the period of relaxation. Among those which occur in the first period are to be noted uncontrollable and violent struggling and vomiting.

Violent struggling is attended by some dangers, particularly in cases where chloroform is employed and in alcoholics. In this class of patients there is sometimes alarming cyanosis, demanding immediate withdrawal of the anesthetic. The suggestion to administer to alcoholics hypodermically a full dose of morphin fifteen or twenty minutes beforehand is a valuable one. It renders the patient much more amenable to the anesthetic agent.

Nausea and **vomiting** also occur before the patient is fully under the influence of the anesthetic, particularly if he has partaken of food or drink during the preceding few hours. This vomiting may become a source of grave danger on account of the passage of the vomited matter into the air-passages, producing suffocation. On the occurrence of this complication the patient's head should be turned to the side so as to facilitate the expulsion of food from the fauces and mouth. If this does not suffice, the index-finger is to be forced over the back of the tongue, bent like a hook, and used to withdraw any mass of food lying in the fauces. The stomach being once emptied, the anesthetic may be proceeded with. The occurrence of deep anesthesia will serve to assist the retching which sometimes follows the emptying of the stomach.

In case suffocation threatens during vomiting, tracheotomy should be at once resorted to. The inspired portions of food will usually be coughed out of the tracheal wound.

A condition of **asphyxia** is sometimes observed to come on without any preliminary vomiting. It is noticed that the patient makes vigorous efforts at breathing but no air enters the glottic opening. The patient's face becomes bluish-red and finally deep purple or dark blue. As anesthesia advances, the muscles of the tongue become paralyzed, and this organ sinks, from its own weight, so as to occlude the chink of the glottis. Under these

circumstances the fingers of the anesthetizer, placed behind the angles of the jaw on each side, flex the head sharply backward and at the same time force the lower jaw anteriorly, so as to cause its lower incisors to project as far as possible beyond the incisors of the upper jaw. The anterior insertion of the geniohyoglossus is thus forced forward and the tongue must necessarily follow. Kappeler seizes the body of the hyoid bone and drags it anteriorly, together with the base of the tongue. If this maneuver fails to lift the tongue away from the glottis, this may be effected by grasping it with the tongue forceps (Fig. 63, G), or an ordinary pair of dressing or hemostatic forceps. If it is necessary to continue the lifting of the tongue, less injury will be inflicted if a thread is passed through the organ, made into a loop and held by the anesthetizer. The thread should be passed crosswise to the tongue near its dorsal surface, at a point behind the attachment of the frenum, in order to prevent dragging on the latter. Sometimes, even in spite of this, it will be necessary to press the tongue downward and forward, by the aid of the finger placed in the mouth.

When masseteric spasm is present, the jaws should be forced apart by a screw-gag (Fig. 63, E), and a lever mouth-gag (Fig. 63, F) introduced to hold the lower jaw down. The arrested ingress of air and ether vapor incident to the blocking of the upper air-passages by the base of the tongue is frequently due to the combined effects of masseteric spasm and involuntary efforts at swallowing. Forcing open the mouth by a gag, so as to put the muscles freely on the stretch, relieves the spasm, interrupts the swallowing act, and gives access to the cavity of the mouth for the purpose of either depressing or drawing forward the tongue and clearing the fauces of mucus or saliva.

Anesthesia in Face Operations.—Full surgical anesthesia is first established, after which the pharynx is cocainized. Two full sized drainage-tubes are passed through the nares to the level of the epiglottis and allowed to project beyond the nose a sufficient distance to permit the administration of the anesthetic away from the field of operation. The mouth is then widely opened, the tongue drawn out, and the pharynx packed with large pieces of gauze. If the base of the tongue is carried well forward an air chamber is formed, with which the rubber tubes and the larynx communicate. A Junker inhaler (Fig. 69), or other apparatus for vaporizing the anesthetic agent, may be connected with one of the tubes.

When this method is employed, the patient may be placed in the position best suited to the operative technic, regardless of the flow of blood. The flow of mucus usually incident to operations within the cavity of the mouth is absorbed by the gauze (Crile).

LOCAL ANESTHESIA

This is best effected by the use of cocain hydrochlorate. Locally applied this drug produces anesthesia, and, in addition, a condition of anemia due to contraction of the arterioles. The mucous membranes are promptly rendered anesthetic; the intact skin, however, is not affected by the drug. Personal idiosyncrasy is an important factor in its use. In those specially susceptible to its effects a few drops of a 4 or 6 per cent solution in the eye or nasal passages, or $\frac{1}{8}$ of a grain administered hypodermically, may produce alarm-

ing depression. Experiments on animals show that the fall of blood-pressure following such manipulations as ordinarily produce shock, abdominal section and manipulation of the intestines, manipulation of the larynx, stimulation of the vagi, etc., is inhibited by the effects of cocain (Crile).

In the surgery of the immediately accessible mucous membranes, *e. g.*, the nasopharynx, larynx, urethra, bladder, etc., solutions of from 4 to 6 per cent are necessary.

In order to secure the anesthetic effects of cocain in tissues other than mucous membranes it is necessary to bring the drug in contact with these either through the use of hypodermic injection or by prolonged contact through wounds or incisions.

The Sterilization of Cocain Solutions.—This is best accomplished by repeatedly heating the solutions to a point just below the boiling-point (fractional sterilization). Boiling injures the anesthetic qualities of the cocain.

The Local Infiltration Method (Halsted, Schleich).—This consists in injecting a 0.1 per cent solution into the substance of the skin. The resulting elevation of the epidermis is called a **wheal.** The first wheal is made by introducing the needle in a slightly oblique direction for a short distance only. The needle is then advanced and a small quantity again injected. Successive wheals are thus formed in the area to be incised. In operations involving deeper parts these must be cocainized in the same manner. In larger areas, in order to avoid the toxic effects of the drug, edema of the parts obtained by the injection of normal salt solution will produce anesthesia in these.

Perineural Infiltration.—This consists in infiltration of the tissues about the nerves supplying the parts to be operated on, proximal to the point of intended operation (Halsted, Oberst). A constricting bandage is placed about the parts a short distance above the seat of operation (Corning). The anesthetic effects are enhanced and the toxic effects lessened by the retention of the solution in the tissues for from half an hour to an hour. The constriction should be just sufficient to arrest the volume flow of blood in the vessels. The tissues about each nerve supplying the parts are infiltrated. The injected solution should be retained for at least half an hour, by keeping the bandage on for that length of time.

Intraneural Infiltration.—The nerve-trunk is first exposed by the ordinary infiltration method, and then injected with from 0.25 to 0.5 per cent cocain solution. The first injection is made beneath the sheath of the nerve; the substance of the nerve is then injected (Crile, Matas). Not only does the injected cocain render the operation painless, but the physiologic "block" produced arrests all afferent impulses and thus prevents shock.

The preliminary injection of a dose of morphin ($\frac{1}{8}$ to $\frac{1}{4}$ of a grain) is recommended in all cases of cocain anesthesia.

Eucain β, the hydrochlorid of benzoyl, is sometimes used as a substitute for cocain, on account of its much less pronounced toxic properties when large quantities are to be employed. It can be sterilized by boiling and its solution will remain unchanged. For the bladder or urethra 4 per cent solutions are employed. Solutions of from 1 to 2 per cent are employed for perineural and intraneural injections. The resulting anesthesia is more rapidly produced but is less lasting than cocain anesthesia.

Tropacocain Hydrochlorid.—This is derived from a special variety of coca plant found in Java. It is said to be less toxic than cocain and to produce a more rapid and trustworthy anesthesia.

Nirvanin.—This is a synthetic product. It is freely soluble in water. When used on sensitive mucous membranes, such, for instance, as the conjunctiva, a temporary irritation precedes the anesthetic effect. The anesthetic effect is in proportion to the sensitiveness of the surface to this precedent irritation. It is specially adapted for subcutaneous use, the resulting anesthesia being complete and prolonged. It is used in from 2 to 5 per cent solutions. The solution may be boiled without injury to the drug. Its toxic qualities are said to be less than those of cocain and eucain. Antiseptic properties also are claimed for it.

Orthoform.—This synthetic compound occurs as a white and very light powder. Its slight solubility in water renders it useless for subcutaneous administration. Its employment is limited to applications to painful lesions of the skin and mucous membranes. It is used as a dusting-powder or in a 10 or 20 per cent ointment. It may be given internally in doses of from $7\frac{1}{2}$ to 15 grains for the relief of gastralgia. Loss of sensation occurs in from three to five minutes following its application to an ulcerated surface or an open wound, and lasts, according to Cheatham, for from thirty hours to three or four days (Patton). Its value as a dusting-powder is enhanced by its drying action. Finally, it may be applied freely and for protracted periods without fear of toxic effects.

Aneson.—A watery solution of acetone chloroform is known by this name. Its anesthetic effect is more quickly produced than that following cocain, but is less pronounced. It is used in 1 or 2 per cent solution for application to the conjunctiva and the nasal, pharyngeal, and laryngeal mucous membranes. The solutions are said to be antiseptic and hence sterile. It may also be used subcutaneously. It is said to be both nontoxic and nonirritant.

Ethyl Chlorid (Kelene).—The local anesthetic effects of ethyl chlorid are due to the intense cold produced. It is furnished in hermetically sealed tubes (Fig. 68) with a screw cap covering a fine point. The liquid is expelled from the latter by the warmth of the hand, in a fine stream, which is directed on the surface to be anesthetized. Temporary congelation occurs, as evinced by the white solid appearance of the anesthetized spot. The anesthetic effect ceases in a few minutes. Its inflammability necessitates caution in its use near an open flame.

Liquid Air.—This has been used as a local anesthetic in the shape of a spray. As in ethyl chlorid anesthetization, the anesthetic effect depends on congelation. A slight tingling accompanies the process. In order to obtain the best results the parts should be frozen solid. The freezing effect produced lasts for about twenty minutes and is succeeded by hyperemia. It is sometimes used to alleviate neuralgic pains. It has also been employed to abort furuncles, buboes, etc., and has been applied at intervals of three or four days as a stimulant to chancres, chancroids, and indolent ulcers.

SPINAL ANESTHESIA

This is more properly termed "spinal analgesia," since only the sensation of pain is abolished by its use. The effect is obtained by the injection of cocain

into the subdural space in the lower dorsal and upper lumbar regions of the cord and cauda equina (Corning). Pure crystallized hydrochlorate of cocain is sterilized by exposure for fifteen minutes to a dry temperature of 300° F. and kept in sterile tubes until needed. The dose varies from $\frac{1}{2}$ to $1\frac{1}{2}$ grains according to the effect desired. Complete analgesia of the entire body, except the head, may be obtained by this method. In exceptional cases the scalp to the vertex also becomes analgesic. A glass hypodermic syringe with asbestos piston is easily sterilized by boiling and is the best instrument to employ. The edges of the beveled point of the needle should be ground off to prevent punching out a portion of the skin. The injection may be made with the patient sitting, or, better still, lying on the side with the back curved. The needle is introduced between the third and the fourth lumbar vertebra. Its entrance into the subdural space is announced by the escape of a few drops of cerebrospinal fluid. The cocain is dissolved in 30 minims of sterile water, the syringe attached to the needle, and the solution slowly injected. The needle puncture is sealed with a drop of collodion. Or the cocain may be placed dry in the syringe barrel, the latter screwed in place, and sufficient cerebrospinal fluid withdrawn to effect the solution of the cocain, which is then injected.

The analgesic effect is obtained in from five to ten minutes. Exceptionally a longer time is required. The abolition of sensation usually commences in the feet and gradually extends upward. The average height reached is the level of the umbilicus. With larger quantities of the solution greater diffusion is obtained, but the use of larger doses of the drug is followed by alarming symptoms of faintness, nausea and vomiting, and signs of collapse. On the other hand, larger dilutions of a safe dose may lead to failure. The effect lasts from forty-five minutes to three hours.

All operations on the lower extremities, genitals, anal region, bladder, and groins (hernia, etc.) may be performed under spinal analgesia. Ovariotomy, hysterectomy, appendectomy, gallbladder operations, and even operations on the thorax have been performed by this method. The last-named operations, however, are not advisable, for the reasons above given.

The method should not be used as a routine procedure and can never replace ether and chloroform. The toxic effects of cocain (great depression, profuse sweating, etc.), as well as the symptoms due to increased tension (intense headache), are common. Besides these, the nausea and vomiting are frequently persistent, together with relaxation of the sphincters and cramps in the limbs. Overaction of the heart and precordial distress are not uncommon. Old and somewhat feeble patients, in my experience, suffer less from these symptoms than the young and vigorous.

Spinal cocainization should be reserved for those individuals in whose cases, on account of the presence of either heart disease, pulmonary disease, or renal disease, a general anesthetic is contraindicated.

SECTION X

THE GENERAL PRINCIPLES OF OPERATIVE TECHNIC

THE SEPARATION OF TISSUES

Tissues are separated or divided for either diagnostic or therapeutic purposes. **Exploratory incisions** are employed for reaching deeply placed diseased foci for purposes of inspection and palpation.

Indications.—(1) The separation of the destroyed tissues from the intact tissues in recent injuries; (2) the fashioning of irregular wound surfaces for coaptation; (3) aid in the search for foreign bodies; (4) the exposures of bleeding vessels for purposes of ligation; (5) the introduction of drainage-tubes; (6) the evacuation of the products of inflammation (pus and other debris); (7) access to inflamed structures for the removal of infected tissues, blood-clot, etc., and the application of antiseptic remedies; (8) the extirpation or destruction of tumors; (9) the removal of parts hopelessly infected or diseased; (10) plastic procedures and the correction of deformities; (11) ligation of blood-vessels in continuity; (12) transfusion; (13) the expsoure of underlying parts to be operated on, as in trephining; (14) abdominal section or celiotomy; (15) herniotomy.

Fig. 70.—Scalpels.

Means Employed.—The following are the principal means employed for separation of the tissues: (1) cutting instruments; (2) blunt instruments, including the elastic and wire ligature; (3) cauterization; (4) puncture; (5) the sharp spoon or curet.

Cutting Instruments.—These include the scalpel and its modifications, the scissors, for separation of the soft parts, and the saw, the chisel, the cutting forceps, and the drill, for the osseous and cartilaginous structures.

The scalpel (Fig. 70) is employed for free-hand incisions and dissections of the soft parts. The blade should be solidly attached to the handle, as in the case of those with hard-rubber handles in which the handle is vulcanized.

on the stem of the blade (Tiemann); either this, or the entire instrument should be forged in one piece. The blade may be narrow and pointed for puncturing and short incisions, and broad and convex, or "bellied" on its cutting-edge, for long incisions and extensive dissections. Scalpels with slightly concave blades (hollow ground) are preferable. The handle should afford a firm and easy grasp for the thumb and fingers and the extremity of this part of the instrument should have a "fish tail" shape for blunt dissection. A double-edged scalpel is useful in certain plastic operations. Knives with stout handles which may be grasped with the entire hand are provided with short heavy blades for operations on bones and joints and with long blades for amputations. The **bistoury** (Fig. 71) is another modification of the scalpel. It may be straight or curved and pointed or blunt.

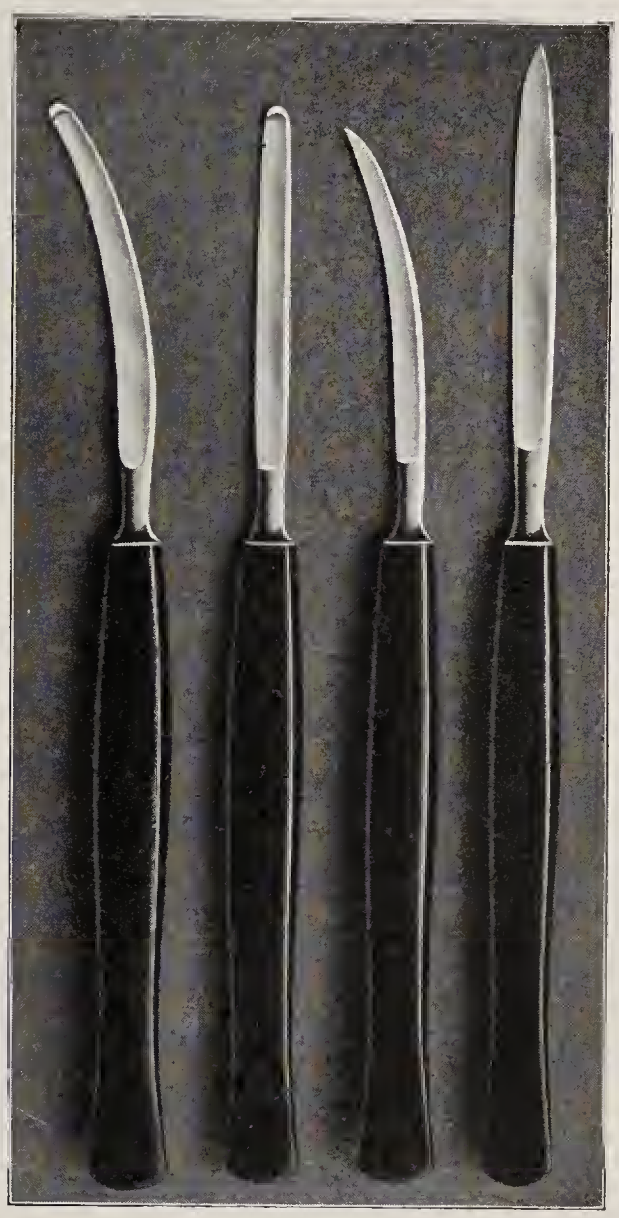

Fig. 71.—Bistouries.

In the separation of tissues from without inward, it is necessary in some localities, on account of the loose connections of the skin to the underlying structures, to make tension on the tissues in order to facilitate incision. The skin may be put on the stretch (1) by the thumb and finger-tips of the surgeon's left hand; (2) by the hands of the surgeon and his assistant; (3) by the flexion or extension of joints, and rotation and extension of the head in operations about the neck. After the skin has been incised, the underlying structures are steadied by anatomic or thumb forceps (Fig. 72), held by the surgeon himself, by his assistant, or, better still, when the latter is well trained, by both. Different forms of fixation forceps have been devised for special operations, such as the double tenaculum forceps (Fig. 73) for grasping tumors and steadying the same during enucleation, and the ring-bladed or fenestrated clamp (Fig. 74), for grasping soft parts which would otherwise tear if grasped by tenacula, such as hemorrhoids during extirpation.

The different methods of holding the scalpel are shown in Figs. 75, 76, and 77. The surgeon's own tact and ingenuity will suggest to him the conditions to which these positions are best adapted.

Incisions from Within Outward.—These are made either with a probe-pointed or a sharp bistoury; when employed to enlarge or to expose the extent of a fistulous tract, a curved blade answers best. When a pointed bistoury is used for this purpose, it is prevented from penetrating beyond the fistula or sinus by the preliminary introduction of a grooved director as a guide (Figs. 79 and 80). Except under these circumstances and in special cases, such as external urethrotomy and perineal lithotomy, the surgeon

should depend on his knowledge of anatomy and execute incisions in a free-hand manner.

Separation of the Tissues by Means of Scissors.—The blades of the scissors should be properly fitted and well sharpened, in order that

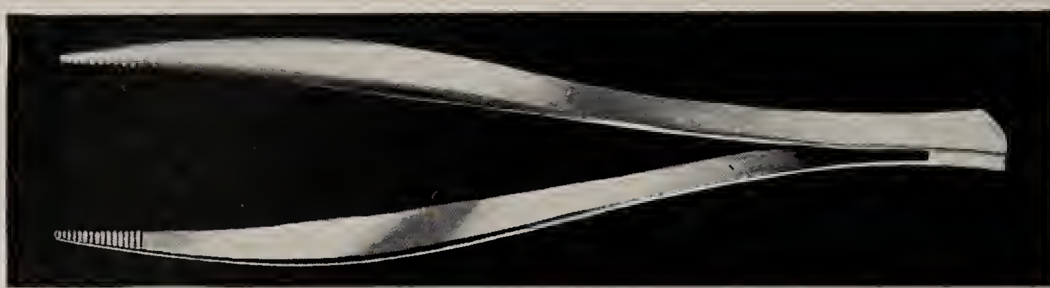

Fig. 72.—Anatomic or Thumb Forceps.

the incision should be as clean as possible; at the best the tissues are more or less pinched and contused by the opposing blades. The steadiness with which the parts are held by the scissors as they are incised constitutes an advantage in the use of this instrument. They should not be employed where

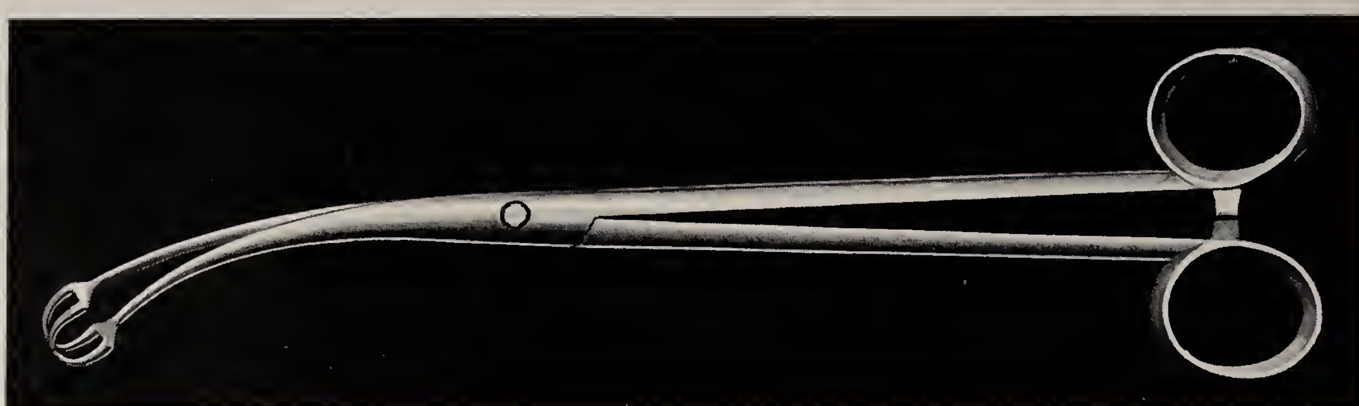

Fig. 73.—Double Tenaculum Forceps.

the vitality of the structures is already impaired and gangrene or sloughing is to be feared. The hand, in grasping the scissors, covers more or less the field of operation and obstructs the view. This is obviated somewhat by scissors curved on the flat (Fig. 81, A). In prolonged operations, as, for instance, in removing multiple lymphomas from the cervical region, the alternate use of the

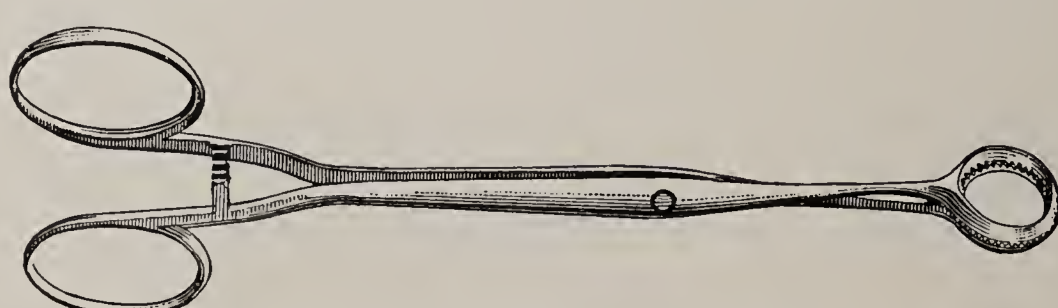

Fig. 74.—Ring-shaped Pile Forceps.

knife and scissors lessens the fatigue incident to the continuous use of one instrument, inasmuch as different sets of muscles are employed for each.

Besides straight scissors and those curved on the flat, there are other shapes which may be advantageously employed, *e. g.*, angular or those curved on the side (Fig. 81, C).

The Separation of Bone.—This is accomplished by means of the saw and its modifications, chisels, cutting forceps, and drills. **Saws** are made with solid broad blades for sawing squarely across the bone (Fig. 82). A narrow

Fig. 75.—Method of Holding the Scalpel for a Long Sweeping Incision.

Fig. 76.—Method of Holding the Scalpel for Dissecting.

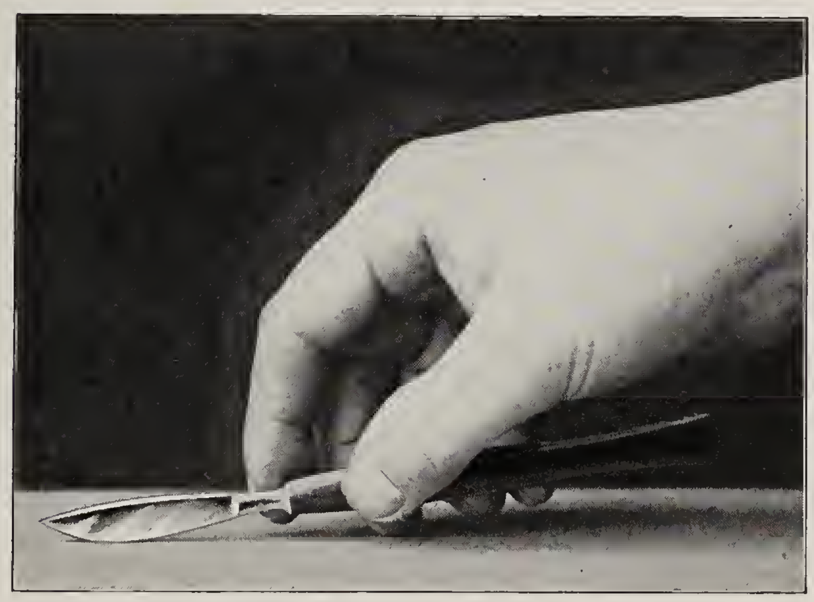

Fig. 77.—Scalpel Held Like a Violin-bow.

blade fixed in a frame is useful in making irregularly shaped cuts (Fig. 83). The chain saw and the wire saw are used in separating bone from within outward (see page 312).

In commencing the section the saw should be drawn at first across the bone from the heel to the point of the instrument in the direction toward the operator, in order to secure a groove for the subsequent strokes of the instrument. This preliminary backward stroke can be made more steadily than a forward stroke over the smooth bony surface, so that the operator is thus enabled to place the groove at the proper point, the saw subsequently following the groove in completing the section.

Fig. 78.—Method of Holding Bistoury. Cutting upward as in opening an abscess.

The **chain saw** (Fig. 145) is made of a number of links connected together like the links of a chain, the teeth being set upon the links. A handle is attached to each end, the saw being moved by pulling on one or the other handle.

The **wire saw** of G i g l i (Fig. 147) has largely taken the place of the chain saw. It is made of piano wire with roughened surfaces. It is more easily introduced and occupies less room when in position than the chain saw. It is comparatively inexpensive and is much more readily cleaned and rendered aseptic than the latter instrument.

Fig. 79.—Cutting Upward on a Grooved Director.

The trephine (Fig. 84) is a tubular shaped instrument with saw teeth, designed for removing button-shaped sections of bone. It is almost exclusively used for the vault of the skull. A pin is projected beyond the instrument for the purpose of steadying the latter until a groove is formed by a series of rotating movements.

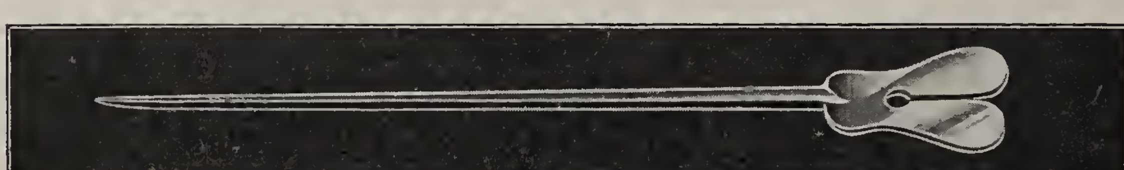

Fig. 80.—Grooved Director.

Care should be taken that the point of the pin does not project far enough to perforate the bone before the groove which is to serve for the sub-

sequent guidance of the instrument is sufficiently deep for the purpose. Though the conical and grooved sides of the trephine of Galt (Fig. 85) are designed to prevent a too sudden completion of the section and consequent injury of the dura, in the case of the skull this should not be trusted too implicitly. The instrument should be occasionally removed and the debris cleaned away for purposes of examination. The sound obtained by tapping on the button of bone at different points with the handle of the instrument will reveal any part which may have been cut through in advance of the rest, in which case the trephine should be tilted away from that point.

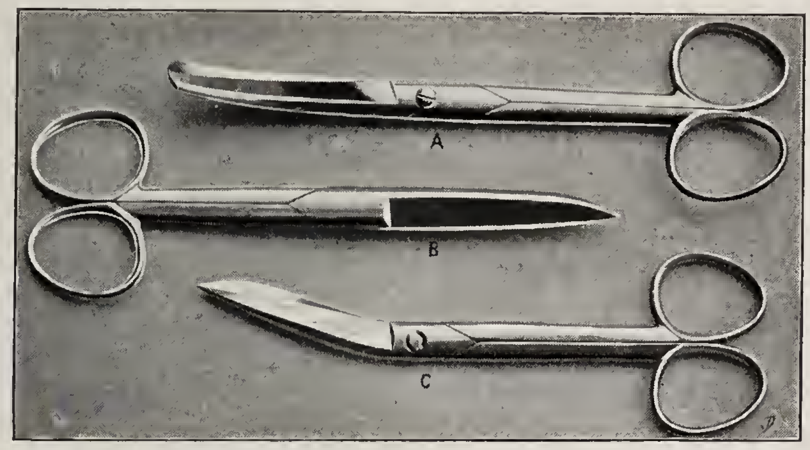

Fig. 81.—A, Scissors curved on the flat; B, straight scissors; C, angular scissors.

Drills are used for perforating bone for suturing and for exploratory purposes (Figs. 86 and 87). In applying the drill the handle of the instrument is grasped in the palm of the hand, the index-finger passing alongside the

Fig. 82.—Broad Saw.

instrument and steadying the latter until its point is engaged. A crochet needle will be found useful in passing the suture. Fluhrer has combined a drill and crochet needle in the same instrument (Fig. 87).

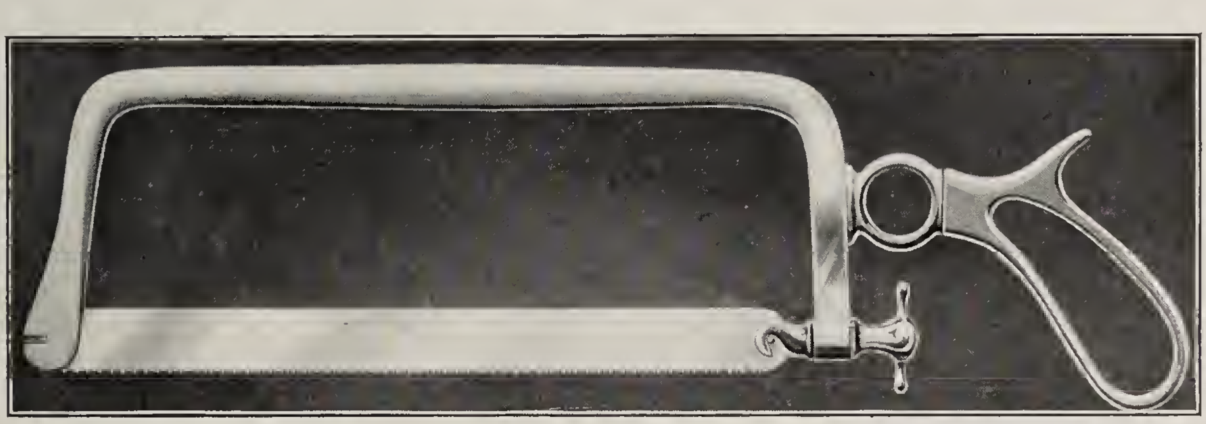

Fig. 83.—Frame Saw.

In recent years the surgical engine, modeled on the lines of the dental engine, has been employed for gaining access to the cavity of the skull and for sawing

and perforating bones in other situations. The electric surgical engine consists essentially of an electric motor, a flexible cable for transmitting the power, and various circular saws, burrs, and drills, together with proper chucks, and

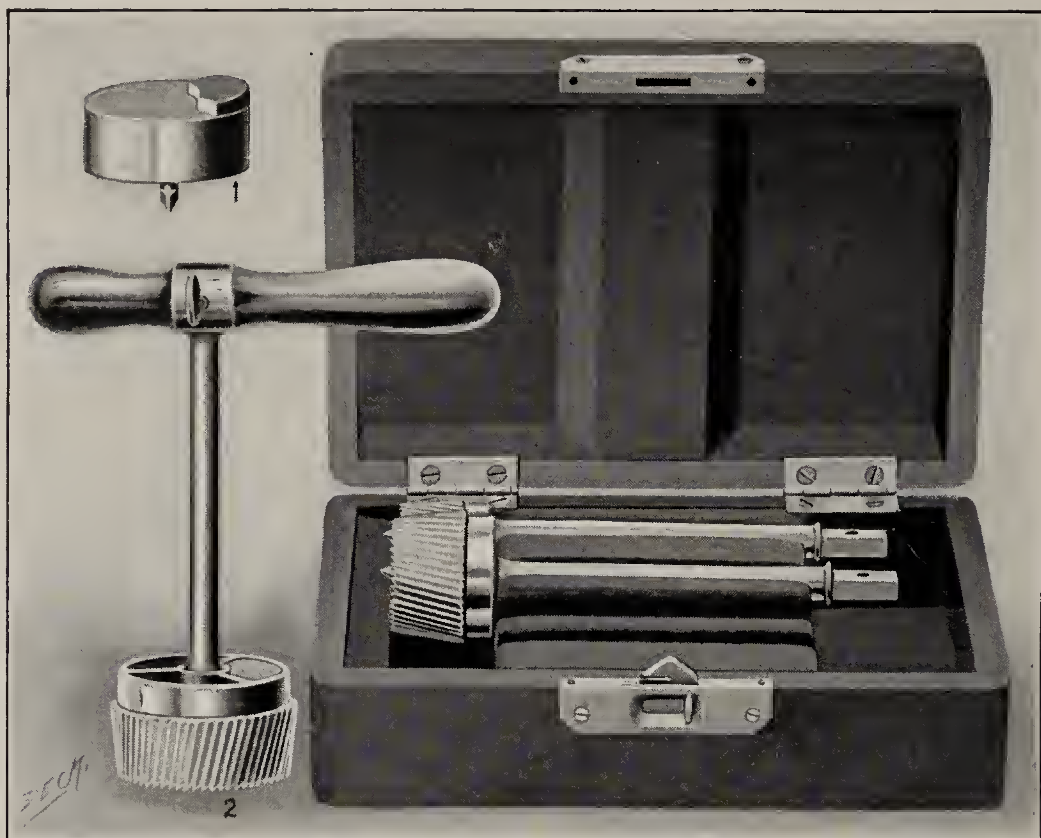

Fig. 84.—Roberts's Aseptic Trephine.
1, Removable block and center-pin; 2, trephine complete.

clutches for securing these to the cable, and handles for guiding the application of these to the work in hand. The best of these is that devised by Doyen, and made by Collin, of Paris (Fig. 88).

Fig. 85.—Galt's Trephine.

Chisels are used for cutting away portions of bone where the saw cannot be applied. They are made in different shapes and sizes, according to the various requirements (Fig. 89). They are used in connection with the mallet. The wooden mallet of the cabinet-maker is the best for the purpose. A little practice will enable the operator to fix his attention on the progress made by the edge of the instrument, rather than on the head of the latter where blows of the mallet are to fall.

Rongeur forceps are used for rounding off or smoothing rough surfaces of bone left after sawing (Fig. 90, A).

Cutting forceps (Liston's, Fig. 90, B) for severing small bones are used where the latter are inaccessible to the saw. Those supplied with hollow blades are used as a punch in removing bone (Fig. 91). When the cutting forceps are used for the division of bones like the metacarpal, a preliminary

groove made with the points of the forceps on one or more sides of the bone will prevent extensive splintering.

The **sharp spoon** or **curet** (Fig. 92) is used for removing diseased tissues from surfaces by scraping movements. It is used for clearing away the infected walls of abscess cavities and sinuses, and the soft and broken-down parts of diseased foci in bone and other structures where a formal dissection is impracticable or where the conditions are such as to render unnecessary the removal of the entire part involved. These curets are made in different sizes;

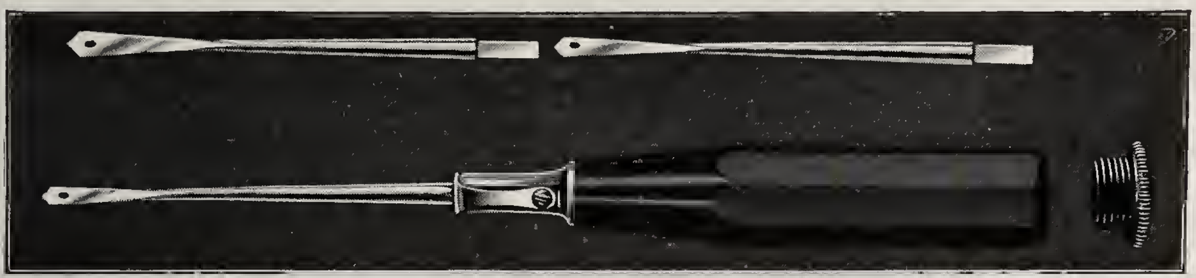

Fig. 86.—Bone Drill, with Hollow Handle to Contain Different Sizes of Drills.

some models have an irrigating attachment to facilitate washing away the debris that results from the scraping.

Separation of Tissues by Means of the Ligature and by Heat.—The simplest method of dividing tissues by these means consists in applying a ligature to the pedicle of a soft tumor, the latter becoming necrotic and falling off. The application of the écraseur is another example of the principle of this method. The instrument may be armed with a chain or firm steel wire (Fig. 95); the latter is preferred in removing nasal and aural polypi. The ligature is sometimes employed when no pedicle exists, *e. g.*, in angioma of the skin, by transfixing the margins of the base with two or more needles carrying a thread in such a manner as to form a series of loops beneath the skin surrounding the

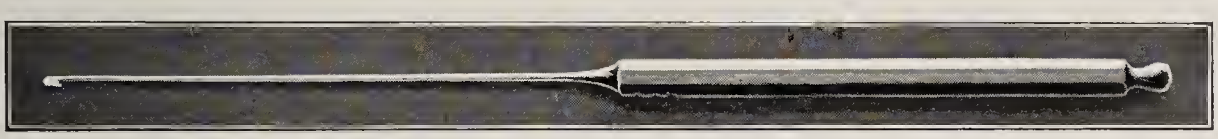

Fig. 87.—Fluhrer's Crochet Drill.

base. By tightening the loops of thread, the base is constricted, a subcutaneous pedicle formed, and the circulation in the growth cut off. Elastic threads may also be employed for this purpose.

The use of the **elastic ligature** has its more frequent application in the cure of fistula in ano. It has likewise been used in effecting lateral anastomosis of contiguous bowel loops (McGraw).

The **galvanocautery loop** is useful in a certain class of cases. The apparatus consists of a loop-carrier, somewhat like an écraseur, which is armed with a loop of platinum wire. The latter is heated by a current of electricity supplied by the street current or a suitable battery. A galvanocautery knife may also be used, as well as a dome-shaped instrument for cauterizing flat surfaces. In addition to the hemostatic properties of the galvanocautery, an aseptic effect is obtained by its use. Recurring or secondary hemorrhage in tissues previously acted on by the cautery is troublesome to deal with on

account of the difficulty of grasping and securing the vessels. Wounds made by cauterization do not admit of primary union.

The **thermocautery** of Paquelin (Fig. 96) is more restricted in its application than the galvanocautery; for instance, it cannot be employed as a hot écraseur.

Fig. 88.—Doyen's Surgical Engine.

1, Electric motor; 2, cable for transmitting the power together with handle and chuck for securing the instruments; 3, larger saws; 4, small saw secured to chuck with guard ring in position; 5, burrs; 6, mortise burrs; 7, drill; 8, chuck shown separately; 9, handle with guard to prevent injury of the dura and saw arranged for section of the bones of the skull; 10, guard rings for the smaller saw; 11, instrument for measuring the thickness of the cranial bones after a small opening has been made.

It has, however, the advantage of being simpler and less expensive. A knife-shaped pointed or flattened dome instrument may be used at will.

Cauterization by Means of Chemic Substances.—These are divided into alkaline and acid substances, and the salts of various metals. The substances belonging to the former group that are in most common use are

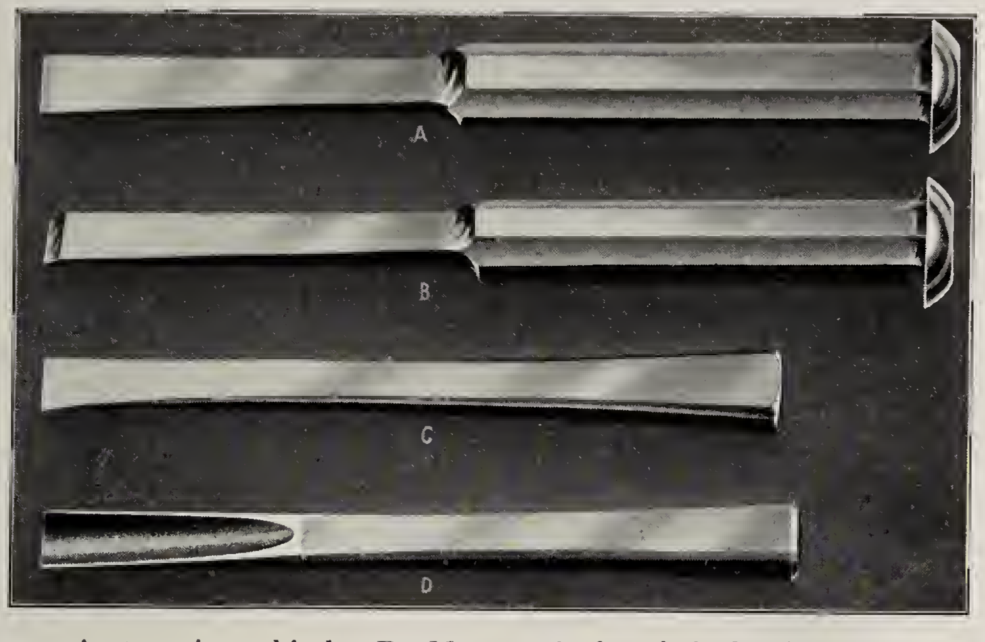

Fig. 89.—A, Macewen's tapering chisel; B, Macewen's beveled chisel; C, light tapering chisel; D, hollow chisel or gouge.

caustic potash and Vienna paste (potassa cum calce, U. S. P.). It consists of equal parts of potassa and lime. These unite with the water of the tissues and dissolve the albuminous bodies. Consequently their action is rather widely

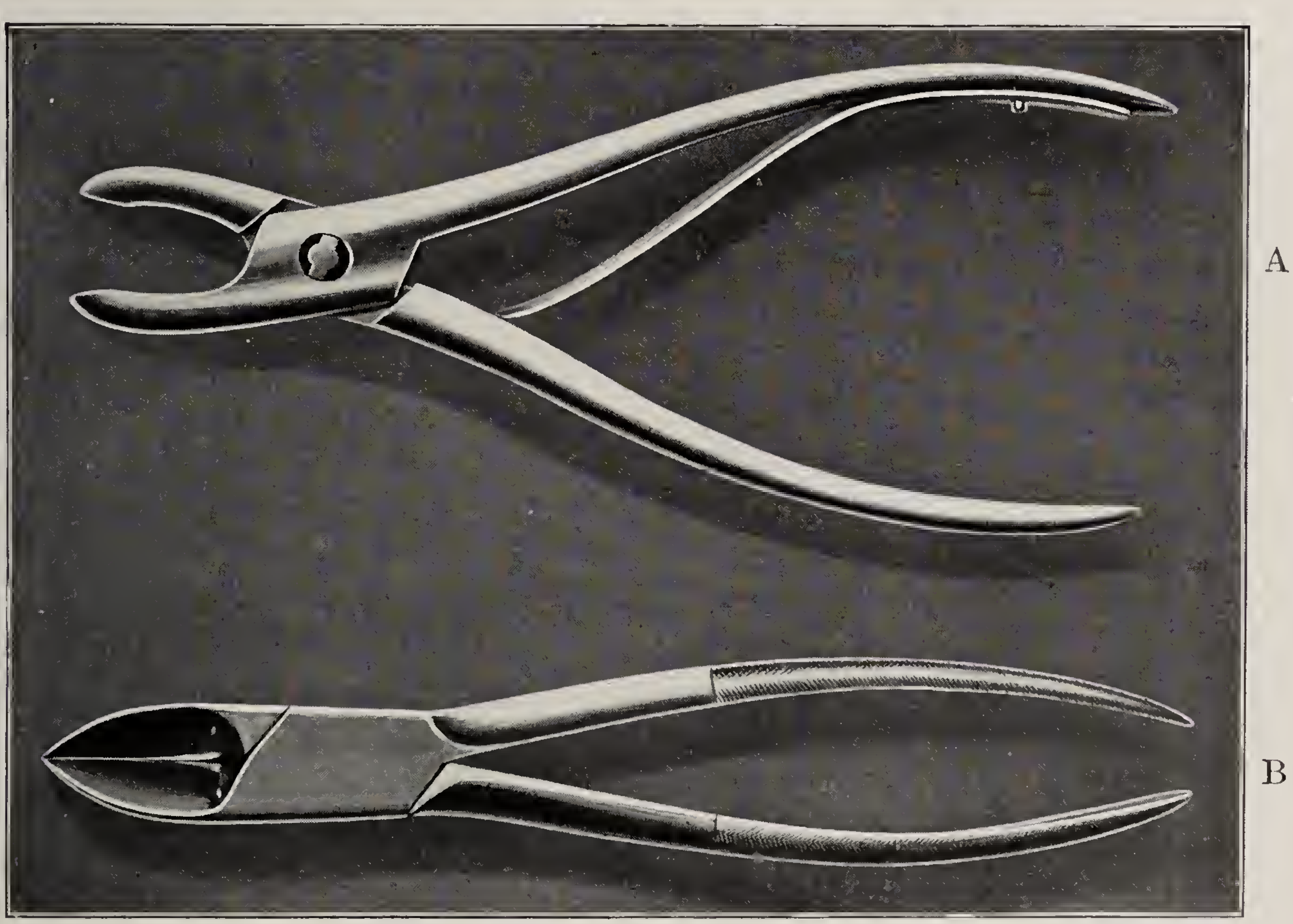

Fig. 90.—A, Rongeur forceps; B, Liston's bone-cutting forceps.

diffused. Alkaline caustics produce a moist eschar which favors the development of bacteria and consequent septic processes. Their use, therefore, is greatly limited.

The acid caustics include nitric acid, hydrochloric acid, and chromic acid. These form, with the coagulated albumin of the tissues, dry eschars. The germicidal effects of the acids and the fact that the action of these does

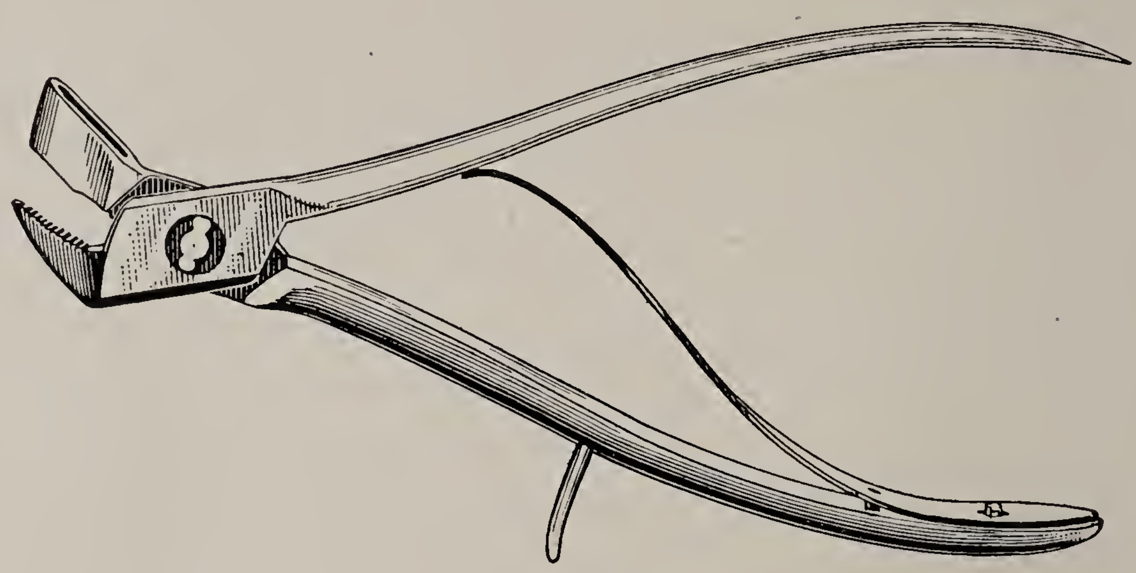

Fig. 91.—Keen's Gouge Forceps.

not extend deeply into the tissues, constitute very decided advantages over the alkaline caustics.

The salts of certain metals are also employed. Nitrate of silver, sulfate of copper, chlorid of zinc, and compounds of arsenic are useful. These act by

Fig. 92.—Volkmann's Bone Curet.

precipitating albuminous substances. Nitrate of silver combined with chlorid of silver to modify its action has but a superficial effect; its use is restricted to the destruction of too rapidly proliferating granulations. Chlorid of zinc

Fig. 93.—Bruns's Bone Curet.

produces a much more intense effect, and the resulting albuminous coagulation is aseptic to a high degree. It may be applied in the shape of a paste (equal parts of chlorid of zinc and flour with sufficient water to make a paste), when

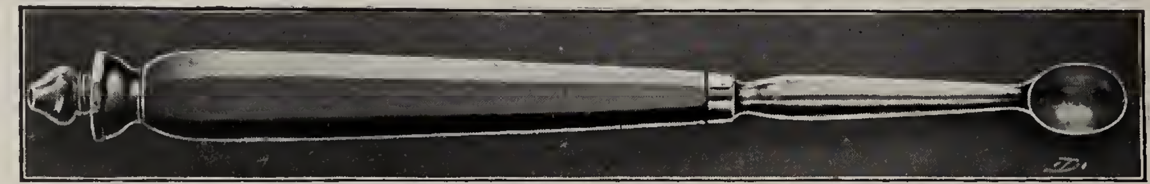

Fig. 94.—Irrigating Curet.

it is desired to produce a deeply destructive effect. It has comparatively slight effect on the unbroken skin.

Caustic arrows are designed to produce separation of parts by their eschar-

otic effect. They consist of strips of heavy linen dipped in a strong solution of chlorid of zinc. The blade of a scalpel is passed flatwise through the base of the tumor to be removed, in a radiating manner, and the arrows are placed in the incisions. The part becomes necrotic and falls off. The process of separation is an exceedingly painful one.

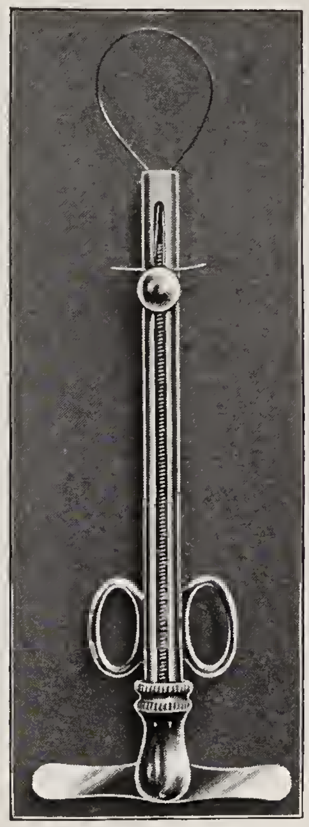

Fig. 95.—Piano-wire Écraseur.

Puncturing and Aspiration.—These methods are employed for the purpose of removing fluids from a diseased part. The puncture made under these circumstances is only of a temporary character. A narrow-bladed scalpel may be employed for the purpose, but a trocar and cannula are preferable (Fig. 97); or the latter, when pointed, may be employed alone. The puncture made, the trocar is withdrawn and the fluid allowed to flow through the cannula. In performing the puncture the index-finger is held as a guard at the proper point to prevent the trocar from penetrating too deeply. A straight trocar and cannula (Fig. 97, A) are usually employed, but it may be an advantage to use a curved instrument (Fig. 97, B), as, for instance, in puncturing the bladder above the pubic symphysis. The pointed cannula or hollow needle is sometimes used, but it has the disadvantage of placing an unguarded point in the cavity to be emptied. To obviate this, the dome trocar and cannula of Fitch is used (Fig. 98). The diameter of the cannula will vary with the requirements of the case. For fluids of a thin character a small instrument will suffice, but those that are thick and viscid or that contain flakes of lymph will require a cannula with large caliber.

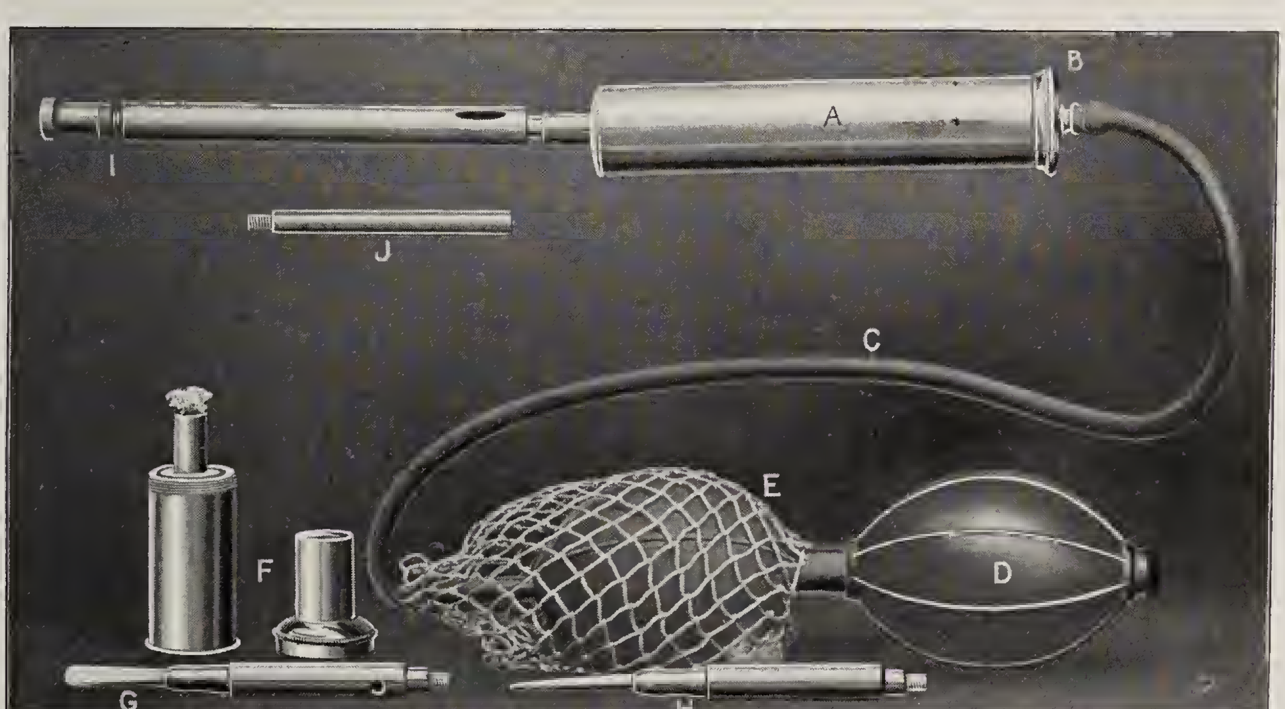

Fig. 96.—Thermocautery.

A, Hollow handle containing absorbent cotton—saturated with benzene; B, removable cap; C, connecting tubing; D, rubber bulb; E, secondary bulb guarded by netting; F alcohol lamp and cap; G, knife-shaped cautery point; H, pointed cautery point; I, dome-shaped cautery point; J, extension attachment to be used with the shorter cautery points.

In case the instrument becomes obstructed, a proper sized wire is passed through it while *in situ* to clear it.

Aspiration is accomplished by attaching a suction apparatus to the cannula.

The aspirated fluid may go directly into the barrel of the syringe, as in Dieulafoy's apparatus; or by exhausting a bottle attached to the cannula, the fluid may be drawn into the bottle instead of into the barrel of

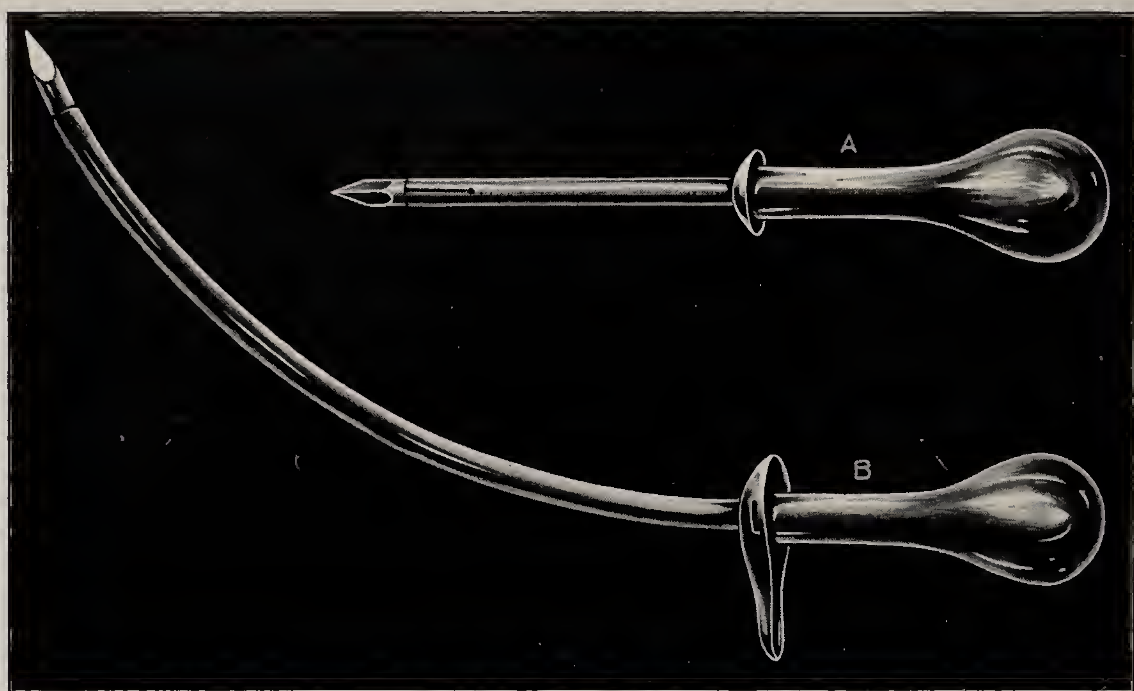

Fig. 97.—A, Straight trocar and cannula; B, curved trocar and cannula.

the syringe (Potain). Puncture for diagnostic purposes is best performed by an ordinary hypodermic syringe (Fig. 99).

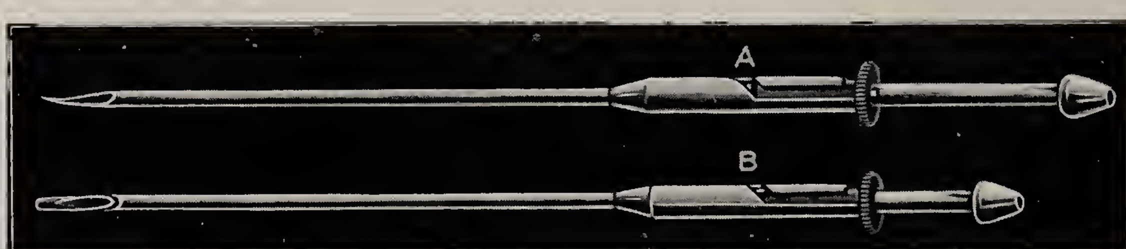

Fig. 98.—Fitch's Dome Trocar and Cannula.
A, The point exposed for introduction; B, the blunt cannula or dome protruded to guard the point after introduction.

The operation of puncturing should be performed with all aseptic precautions. In withdrawing the cannula the vacuum in the syringe or bottle

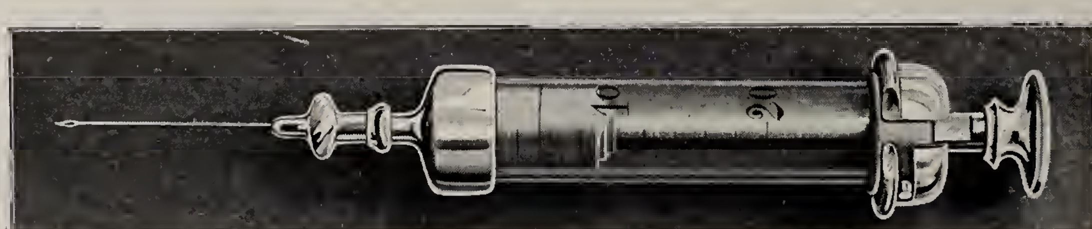

Fig. 99.—Collin's Glass Syringe with Solid Metal Piston.

should be preserved in order to prevent the entrance of air, as well as to guard against contact of the overlying structures with infectious material from the diseased part which otherwise would remain in the point of the instrument.

INDICATIONS FOR UNITING THE TISSUES; MECHANISM OF UNITING THE TISSUES

To secure union of divided structures is the first aim in this connection. The preliminary conditions necessary for this are (1) **prevention of high grades of inflammation**; (2) **effective and permanent coaptation of the wound edges.** The first condition is fulfilled partly by careful aseptic treatment of the wound itself, and partly by the application of aseptic principles in the introduction of the sutures, or the employment of other retentive means.

Formerly the existence of contused wound edges was considered a contraindication to the use of sutures. If the requirements of a rigid asepsis or antisepsis are met, however, it is possible to obtain primary union, even in these cases. But if the crushed tissues are beyond the hope of recovery, either the attempt to apply the suture or the effort to secure coaptation of the edges otherwise must be abandoned, or the crushed tissues must be first removed.

In case of **extensive and deep wounds,** particularly those which have been accidentally inflicted, there will probably be a large amount of wound secretion, and drainage must be provided for. A fenestrated drainage-tube of rubber may be passed the entire length of the wound, projecting at one or both ends. In the latter case the patency of the tube may be assured by "flushing" with a stream of antiseptic solution without removing the tube until it is permanently withdrawn. Finally, **accidentally inflicted shallow wounds of limited area** may be drained by means of a twisted strip of iodoform or other sterile gauze. The large majority of operation wounds made under proper conditions of asepsis may be closed without drainage.

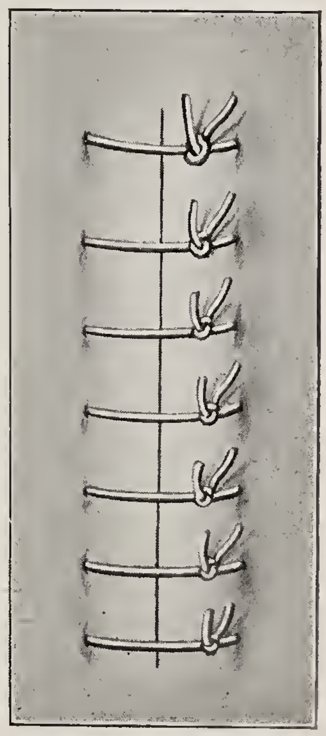

Fig. 100.—Interrupted Suture.

The protection of the line of suturing is of importance. This is usually accomplished by means of a simple gauze dressing. A narrow strip of silver foil affords protection, and at the same time furnishes the base for antiseptic compounds formed by the action of the wound secretions on the metal (Halsted).

Gaping of the wound edges, due to the elasticity of the tissues, is overcome by permanent coaptation. In order to accomplish this, more or less strain is placed on the structures sutured. In case of large wound defects or in tissue naturally unyielding this may be more than they can bear, and there occurs a "cutting through" of the tissues, the latter being forced against the rigid and unyielding thread. Separation of the sutured line takes place and the suture material becomes buried in the tissues. This may also happen from tying the sutures too tightly or from excessive swelling.

The Interrupted Suture.—This consists of a single thread passed by means of a needle through both wound edges and then tied, the latter being at the same time adjusted in their proper relation to each other (Fig. 100). The needle employed may be either curved or straight, according to the requirements of the case. The Hagedorn needle (Fig. 101) is flattened and has a

lance-shaped point. The wound which it makes lies in the same direction as the line of tension when the suture is tightened, hence its edges tend to come together rather than gape, as is the case when the ordinary needle is used. Practically, however, any well-polished and properly shaped needle will answer the purpose. For suturing the peritoneum round wire needles are employed. For suturing other soft tissues, needles with cutting-edges are used. A straight needle may be employed on convex portions of the body, while in concave portions the curved needle is more useful. As a rule, the latter can be used in both, hence this form of needle is most frequently employed. The curved needle may have different degrees of curvature, those representing from one-third to two-thirds of a circle being most commonly used. In addition, needles have been devised for special operations, such as cleft palate, etc.

Fig. 101.—1, The Hagedorn needle; 2, the Hagedorn needle modified by twisting so as to permit it to be grasped with a hemostatic forceps.

In perforating the tissues the thumb and finger may be used for grasping the needle, or preferably, and for aseptic reasons, one of the many varieties of **needle-holders** may be employed (Figs. 102, 103). The needle forceps are particularly useful in deep sutures, or when the density of the latter is such as to require considerable force to drive the needle through them.

In passing the needle through the skin surface there is less risk of conveying infection to the depths of the wound if the perforation is effected from beneath to the surface, instead of from the outer surface of the skin on one side and from beneath on the other. The amount of infectious material in the substance of the skin is almost incredible (W e l c h), and passing a needle from the surface into the wound depths favors infection of the latter. In passing the needle in this manner it is convenient to place a needle on the thread at both ends; and to avoid the annoyance of having the second needle become disengaged from the thread while the first is in use, it may be threaded with a " hitch" or bight (Fig. 104).

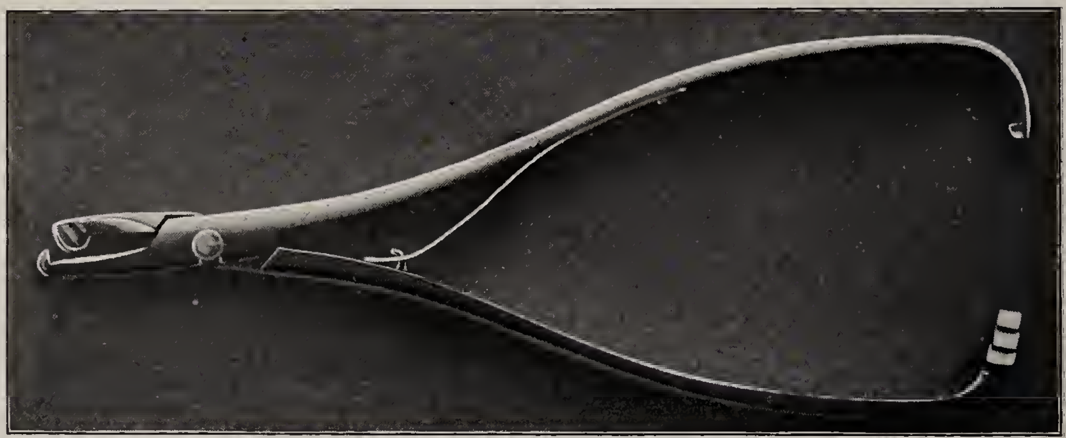

Fig. 102.—Richter's Needle-holder.

Where the parts to be united consist of several distinct layers of tissue, as, for instance, in abdominal section in which peritoneum, muscle and fascia,

and skin are to be united each to its own structure separately, **layer sutures** are employed. These cannot be removed, and hence are called **buried sutures**. For this purpose either catgut or kangaroo tendon may be used. These are sometimes prematurely absorbed and permit separation of the suture line. If of nonabsorbent material, they may become a source of irritation to the tissues. The employment of the **removable layer suture** obviates these disadvantages. With the thread (crin-de-Florence or silkworm-gut being preferred) armed with a needle at each end, each layer is secured separately by passing the needles from the depth of the wound toward the surface. As each successive layer is included in the loop the needles are reversed as regards position before being passed through the next layer, the two legs of the suture crossing each other between the separate layers until the skin surface is reached

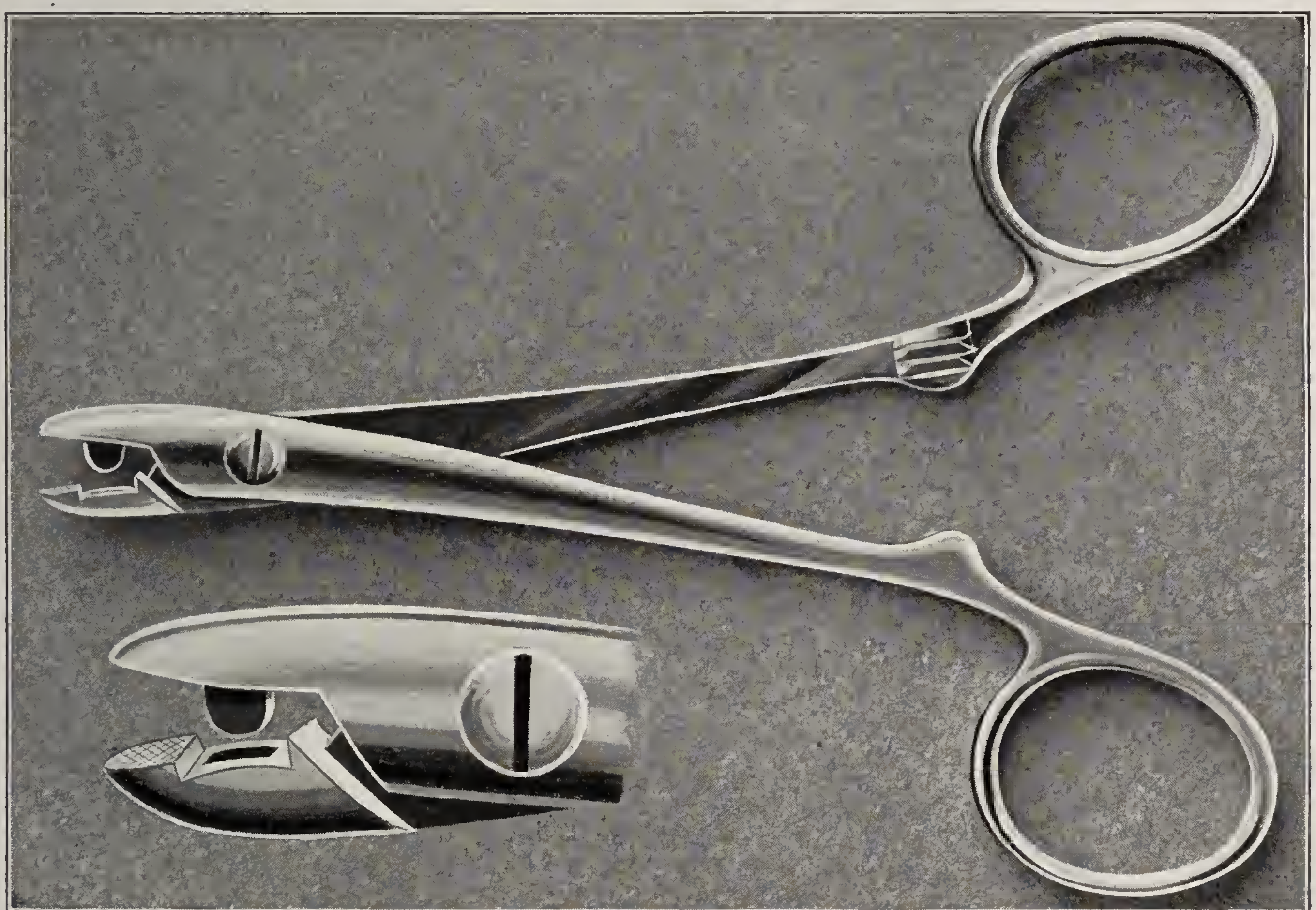
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FIG. 103.—THE RICHTER NEEDLE FORCEPS MODIFIED.
A, The cam and "pick-up" device shown in detail.

(Figs. 105, 106, 107). The sutures are here secured in pairs by "bolsters" of rubber tubing (Figs. 108, 109).

Buried sutures are also employed to obliterate so-called dead spaces, as, for instance, those cavities in the thick fat layer of the abdominal wall of very obese individuals left after operations for the radical cure of ventral or umbilic hernia.

For accurately coapting the skin edges either the interrupted suture or the **continuous suture** may be used. The latter may be employed in a simple over-and-over manner (Fig. 110), or the **intracuticular suture,** in which the needle is passed on the raw edge of the skin, parallel to it, may be used (Fig. 111).

The best form of the continuous superficial suture is the **chain-stitch** (Ford). The needle is passed as in the ordinary interrupted or glover's

suture. Instead of allowing the suture to cross the wound edges at a more or less acute angle, however, the needle is passed beneath what would ordinarily

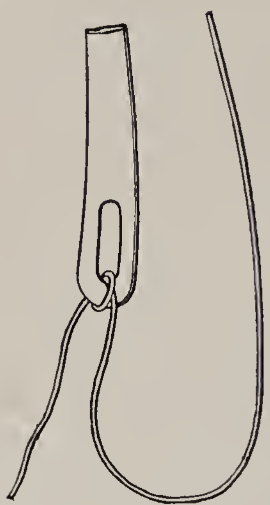


FIG. 104.—METHOD OF SECURING A STRAND OF SILK-WORM-GUT TO THE NEEDLE.

The end of the strand which has been passed through the eye of the needle is passed a second time from the same side as at first. The resulting "hitch" or bight is then drawn tight.

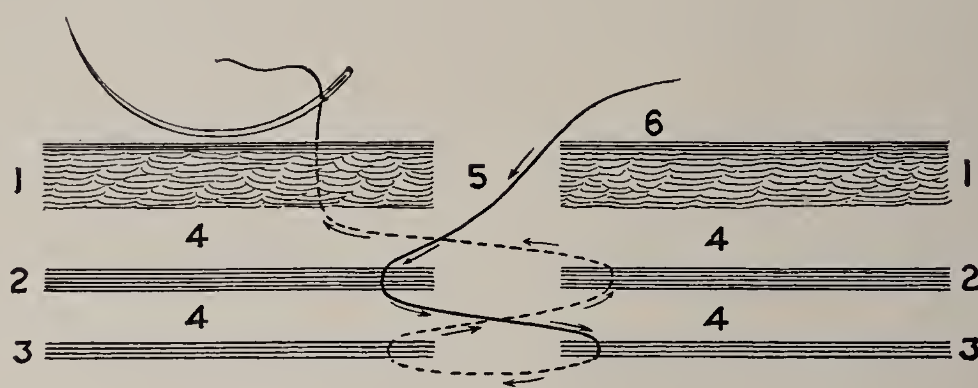


FIG. 105.—THE REMOVABLE LAYER SUTURE.

Method of application with one needle. Schematic, representing a cross-section of the abdominal wall. 1, 1, First layer, consisting of skin, fat, and superficial fascia; 2, 2, second layer, consisting of transversalis muscle, and transversalis fascia; 3, 3, third layer, consisting of peritoneum; 4 4, 4, 4, dead spaces between the planes of the layers; 5, gap representing the wound to be closed; the end of the thread at 5 is armed with a needle and finally passed through the first layer at 6 from within outward to complete the suture.

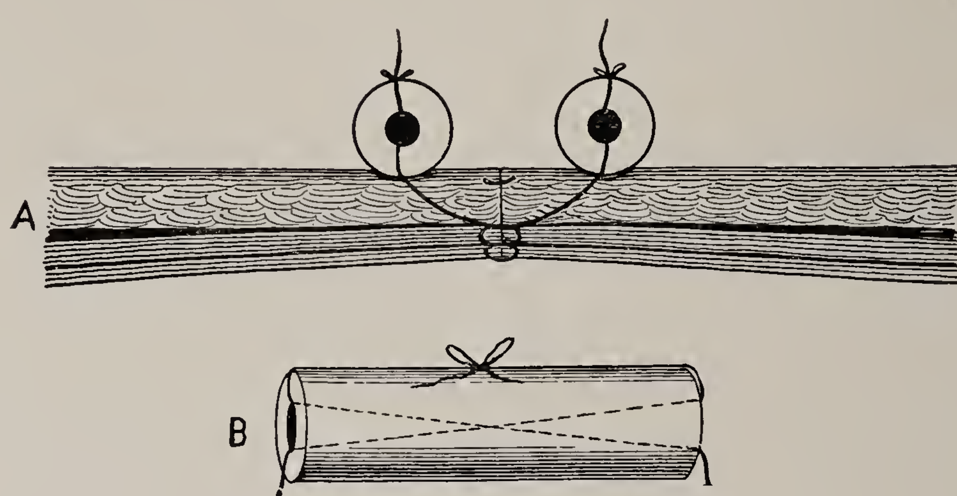


FIG. 106.—THE REMOVABLE LAYER SUTURE.

A, Simultaneous coaptation of the edges and plane surfaces of the layers of the abdominal wall; B, the manner of passing the suture ends through the lumen of the rubber "bolster" when thick-walled tubing is employed.

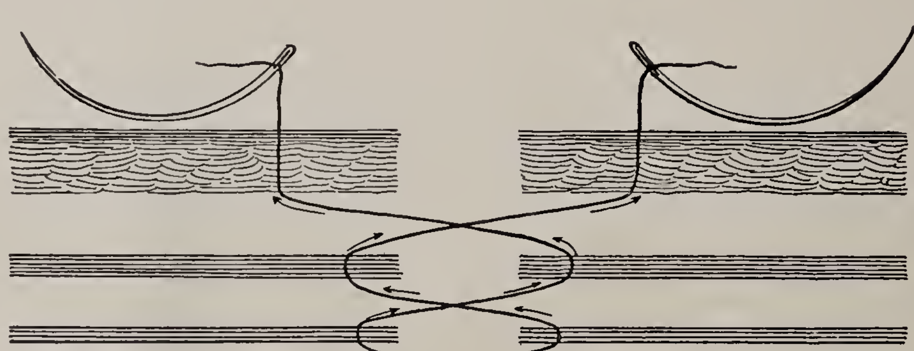


FIG. 107.—THE REMOVABLE LAYER SUTURE.

Method of application with two needles. The relative position of the needles is reversed as each layer is secured, the threads crossing each other as this is done. The arrows show the directions taken by the suture.

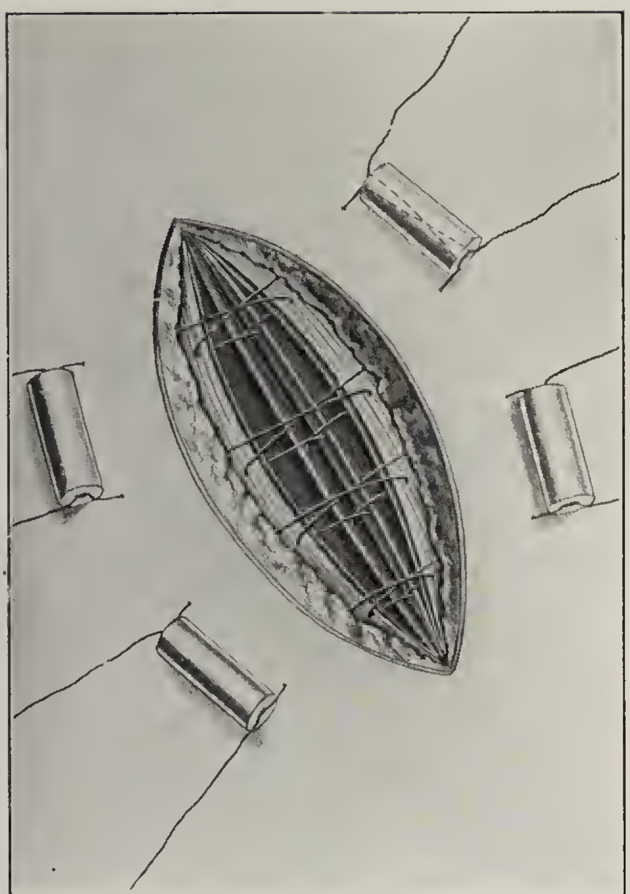


Fig. 108.—The author's figure of 8 removable layer suture, applied to the oblique appendicitis incision, showing the sutures passed through all the layers, including the skin, and the bolsters in position. The dotted lines in the upper right-hand corner show the method of passing the suture through the lumen from each end of the bolster.

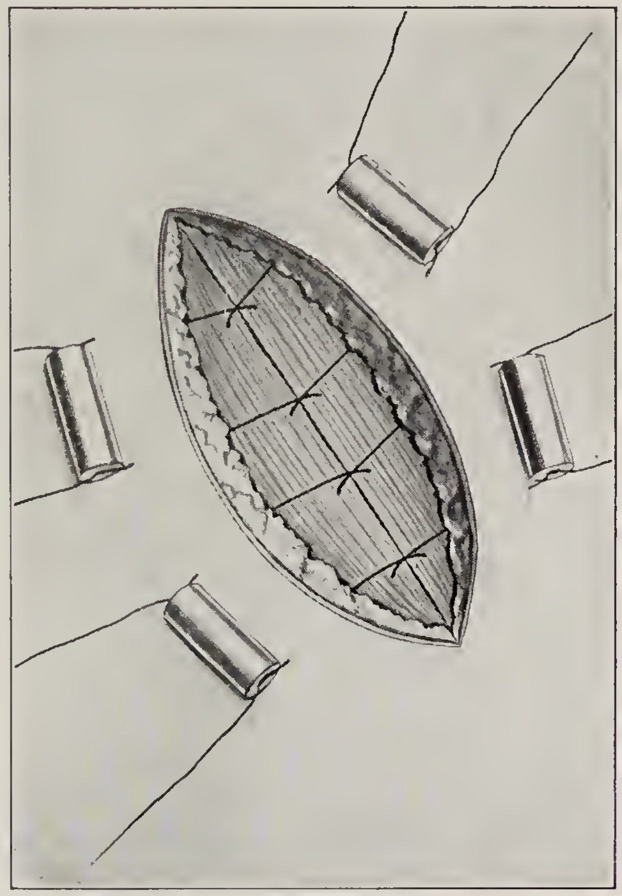


Fig. 109.—The author's figure of 8 removable layer suture, applied to the oblique appendicitis incision showing the sutures drawn sufficiently taut to approximate the edges of the incision in the deep structures. The edges of the skin are shown wider apart than they actually occur, in order to demonstrate the approximation.

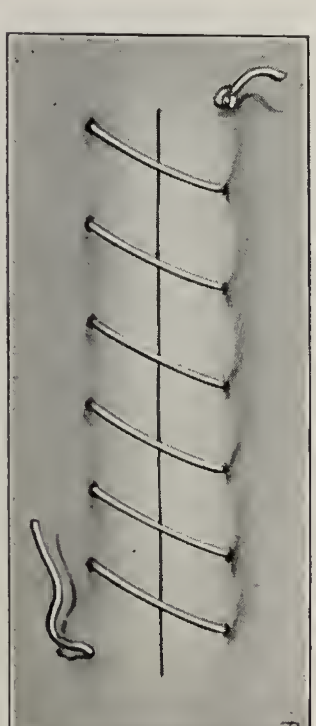


Fig. 110.—Continuous Suture.

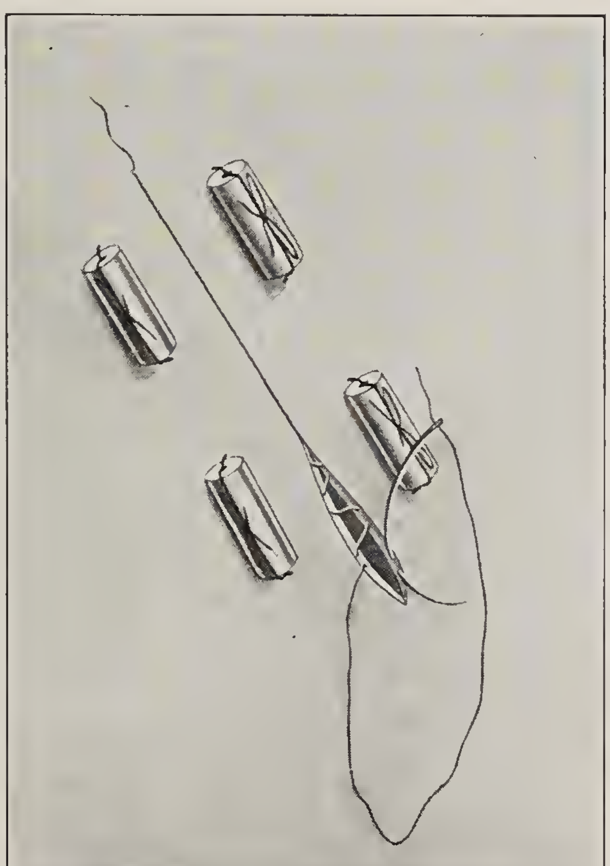


Fig. 111.—The author's figure of 8 removable layer suture, showing the bolsters set, the sutures tied, and the skin edges in course of closure by the intracuticular suture.

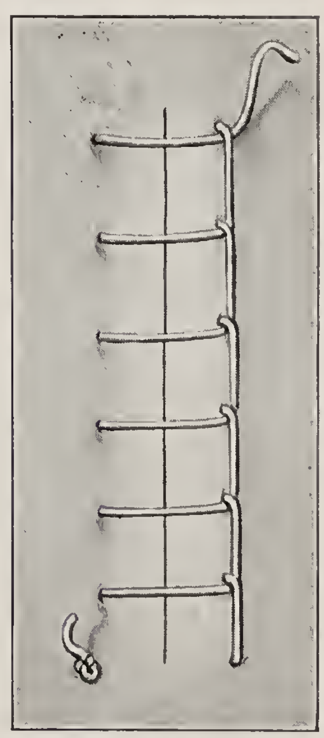


Fig. 112. — Continuous Chain-stitch (Ford's).

be the overlying portion and the stitch drawn taut with this lying parallel to the wound edges. The needle may be passed one or more turns beneath the loop. Several turns should be made at the termination of the suture line in order to secure the suture (Fig. 112). (Special sutures will be described in the part on Regional Surgery.)

Coaptation by Means of Adhesive Plaster.—This is a somewhat unsatisfactory procedure, only the superficial edges of the skin being brought together. It cannot supplant the use of sutures, though it is sometimes employed as a substitute for superficial sutures. When it is thus used, narrow spaces should be left between the strips to permit the escape of secretions from between the skin edges.

SECTION XI

OPERATIONS ON INDIVIDUAL STRUCTURES

OPERATIONS ON THE SKIN

OPENING OF ABSCESSES

Abscesses may arise in the subcutaneous connective tissue, or may invade this region from the deeper parts. In modern surgical practice it is deemed best to empty, curet, and otherwise treat antiseptically suppurating foci as soon as their presence can be demonstrated. This may involve incisions through fascia and muscular structures, as well as through the skin.

The method usually employed in opening an abscess of the subcutaneous connective tissue is that known as transfixion. A curved pointed bistoury is passed with its edge upward through the abscess cavity and the incision effected by a simple stroke outward. By this means the length of the incision can be governed with greater certainty, the incision is made with greater rapidity and hence is less painful. Its length should correspond to the diameter of the abscess cavity if the latter is not more than two inches in diameter. After free incision vigorous curettage, thorough antiseptic irrigation, and "scouring" of the abscess cavity by means of dry aseptic gauze should be employed. In an abscess of more than two inches in diameter a smaller opening or more than one opening (counter-opening) may be made. After irrigation and curettage one or more drainage-tubes are introduced. In making a second opening the edge of the first may be grasped by a dissecting forceps to steady the collapsed abscess wall; or the forceps may be pushed through the first opening to a point opposite, the blades separated, and the parts thus steadied while the second incision is made. A finger is to be introduced and the size and shape of the cavity ascertained; this can then be curetted intelligently. Antiseptic irrigation can be carried on at the same time if the irrigating curet is employed (Fig. 94).

When, either through spontaneous opening of an abscess or through an insufficient artificial opening, the drainage is incomplete, this should be remedied by introducing a probe-pointed bistoury through an already existing opening and withdrawing it vertically, at the same time enlarging the opening. The abscess cavity should then be treated as if now opened for the first time. Undermined portions of skin should be opened up freely, and in some instances may be excised with advantage.

PLASTIC OPERATIONS ON THE SKIN

Plastic operations are resorted to for the purpose of artificially restoring lost portions of the body by means of *living* tissues. The skin forms the most essential material for plastic operations on the surface of the body, by reason of its rich supply of arteries and capillaries.

Heteroplastic operations consist in replacing defects by means of tissue derived from sources other than the individual in whom the defect occurs. This includes transplantation from man to man, or from a lower animal to man. Attempts in this direction are sufficiently encouraging to justify a still further trial of the method.

Autoplastic operations consist in replacing defects by means of tissue taken from the same individual. They are indicated in defects resulting from (1) congenital cleft formations (harelip, cleft cheek, palatal fissures, exstrophy of the bladder, etc.; (2) injuries; (3) thermic and chemic destructive action; (4) chronic ulcerative processes, particularly those arising from varicose veins; (5) the removal of diseased conditions (carcinoma, lupus, syphilitic and tuberculous ulcerative processes); (6) the removal of benign tumors, angiomas, etc.; (7) cicatricial displacement leading to disturbances of shape and function of parts.

The **indications** may be further divided into those of a **cosmetic** and those of a **functional** character. It may happen, as in the case of ectropion of the eyelid, that both cosmetic and functional considerations enter into the question. In the case of injuries the plastic replacement should be attempted at once by means of the part which has been removed. Portions of the nose, fingers, the tongue, etc., should be immediately replaced and sutured in position. The ends of the middle and ring fingers have been successfully replaced seven hours after they had been cut off (Finney). In case the injury is accompanied by more or less crushing or other destruction of the parts, replacement cannot be successfully accomplished.

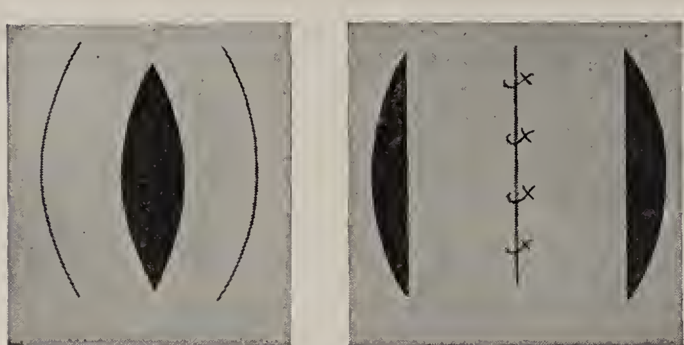


Fig. 113.—Relaxing Incision.

(Plastic operations will be further discussed in Regional Surgery.)

In ulcerative processes from syphilis, tuberculous disease, etc., the local focus must be first healed. In carcinomatous and other tumors in which the diseased tissues have been removed, the plastic operative measure best adapted to the case may be proceeded with at once.

General Methods of Plastic Operations.—Two essential methods are employed. The first consists in the utilization of tissues from the immediate neighborhood; the second in their transplantation from a distant part. The first may be again divided into those methods in which the tissues used to replace the defect are brought into position by **sliding** or **lateral displacement,** and those in which **flap formation** and **torsion** of the pedicle are distinguishing features.

Replacement by means of **lateral displacement** may sometimes be accomplished without the introduction of new tissue. This may be aided by the loosening of the skin structures by means of a dissection carried along the plane of the subcutaneous connective-tissue space, or by the employment of **relaxing incision** (Fig. 113) made parallel to the intended line of sutures, or by both. The gaps left by these relaxing incisions are permitted to heal by granulation. A method of closing a rectangular shaped defect is shown in Fig. 104. Dieffenbach's procedure for closing a triangular shaped defect is shown in Fig.

115. The method of Dieffenbach was improved by Bürow (Fig. 116).

Flap Formation with Torsion.—The advantages of this method are as follows: (1) it admits of almost universal application; (2) the flaps can be more accurately adapted to the defects; (3) tissue free from disease can be

Fig. 114.—Closing Rectangular Gap.

selected for the purposes of the repair; (4) by proper care in placing the pedicle the nutrition of the parts may be more certainly assured. When the transplanted portion is taken from a distant part, the former is approximated to the place of defect; under these circumstances torsion of the pedicle may or may not be employed.

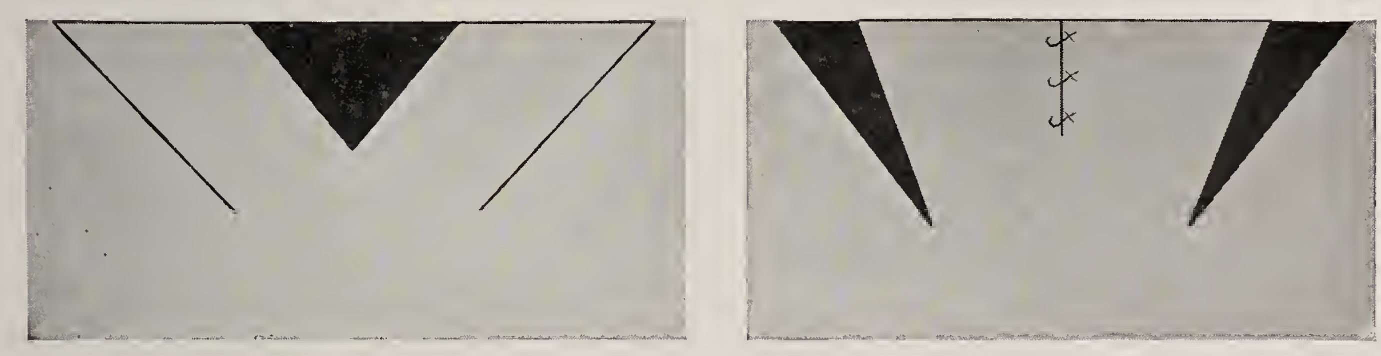


Fig. 115.—Closing Triangular Gap.

The free transplantation of large flaps dissected from the skin and subcutaneous tissue is occasionally employed. There is a greater liability of death of the flaps in this method.

Death of transplanted portions is less likely to follow the method of sliding than any other. In flap operations with torsion the flap must be sufficiently

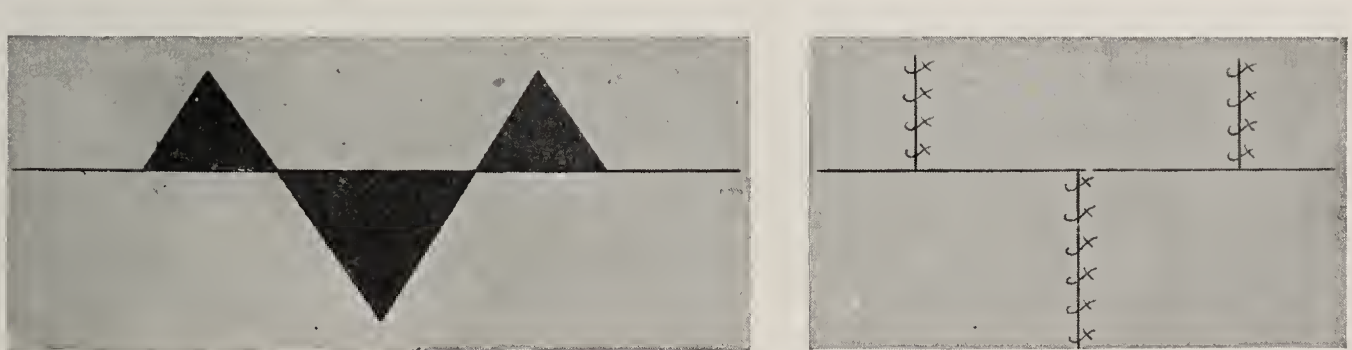


Fig. 116.—Bürow's Modification of Dieffenbach's Method.

narrow, else the twist which it receives may result in undue pressure on the vessels of supply and the occlusion of them. The most important precautions are the following: (1) The pedicle is to be situated in a region from which a fresh supply of vessels pass to the portion to be transplanted; (2) the formation of

the flap must be accomplished with the greatest care, the edge of the scalpel being directed *away* from the skin, particularly when dissecting near the pedicle itself, in order not to injure the vessels in the latter; (3) an accurate isolation of the pedicle is necessary, in order to permit torsion without folding; (4) the stem must be sufficiently long to permit an easy twist. The last is further provided for by extending the incision which marks one boundary of the pedicle somewhat further than the incision which marks the other boundary, so that there is a long and short edge to the pedicle, the long edge representing the edge *from* which the twist is turned. The raw surface of the flap must fit closely on the properly prepared surface of the defect, and the edges of the former are to be accurately sutured to the latter. If the transplanted portion is intended to replace cicatricial tissue, the latter must be dissected entirely away, in order to obtain a normally vascularized surface for the reception of the flap. Aseptic measures must be employed.

Plastic procedures are most successful when there is a rich supply of arterial and capillary vessels, as, for instance, in the facial region. In regions in which the vessels are less plentifully supplied it is sometimes of advantage to loosen the flaps from the subcutaneous connective tissues, and they are thus nourished by a pedicle at each end, gauze dressing or oiled silk protective being packed beneath it. At the end of a week or when a profuse granulating surface has been obtained one of the pedicles is severed and the edges of the flap and defect are freshened. This is called **transplantation of a granulating flap.** It is sometimes employed in operations for exstrophy of the bladder.

Elastic and cicatricial shrinkage of the flap invariably occurs. The former takes place at once and amounts to about one-third of the entire area of the flap. It is to be compensated for by an increase in the dimensions of the transplanted portion over the size of the defect. Cicatricial shrinkage is to be guarded against by bringing the raw surfaces as accurately as possible into opposition, so that primary union rather than the filling of an intervening space by granulation is thereby secured. In rhinoplasty the newly formed part must at first be largely in excess of the original, in order to allow for the shrinkage which occurs in the course of a few months.

Secondary shrinkage of the flap is prevented to a great extent by reinforcing the latter by means of the cicatricial tissues about the defect. For instance, in the case of a defect of the anterior portion of the nose, the skin at the root of the latter is circumscribed by a horseshoe-shaped incision, loosened and turned downward, its wound surface corresponding to that of the flap taken from the forehead (see page 510).

The underlying periosteum may sometimes be employed as a portion of the transplanted structures. In the operation of uranoplasty this is imperative (Langenbeck), and also where cicatricial tissue must be utilized, the vessels between the cicatrix and the periosteum being carried along with the flap.

The flap should empty itself of blood before it is sutured in place. This prevents the formation of coagula which tend to retard the new circulation in the flap. A pale flap is more favorable than a congested one. In the former the supply of blood will probably be reestablished in a few hours; in the latter, retarded return flow and stasis quickly threaten the integrity of the flap.

The restoration of normal conduction of sensation occurs in the course of

time, though at first the sensation may be referred to the point from which the transplanted portion was taken.

Reverdin's Method.—This consists in the implantation of completely separated small flat portions of epidermis which form islands on the granulating surface of the defect. These soon become surrounded by a zone of proliferating epithelium. The transplanted epidermis is not very durable. The outermost layer is cast off, giving every appearance of failure, yet sufficient epithelial structure remains from which further proliferation occurs until the entire surface is covered. The flaps should be of skin only and not more than three-eighths of an inch in diameter. If larger pieces are used they should be elliptic shaped in order better to close the defect. Still smaller pieces may be obtained by picking up a fold of the skin with mouse-tooth forceps and snipping them off with scissors; a large number of these may be scattered over the surface of the defect. A special instrument may be employed (Fig. 117).

Autoepidermic Skin-grafting.—This may be employed to fill in an ulcerated surface or a defect in which repair is under way by granulation. The method is based on the fact that the newly developed epithelial cells are very active in growth at the edges of a granulating ulcer or defect. The surface to be grafted is prepared by gentle curetting where the granulations are weak and flabby; hemorrhage is arrested by firm pressure. The thin blue line of epithelial cells that has formed along the edge of the defect is dissected up and small pieces about one-eighth of an inch square cut off and placed with their raw surfaces down on the granulating surface. The operation is painless. Each graft is covered with a small piece of oiled silk and dry sterile gauze dressing is applied (McChesney).

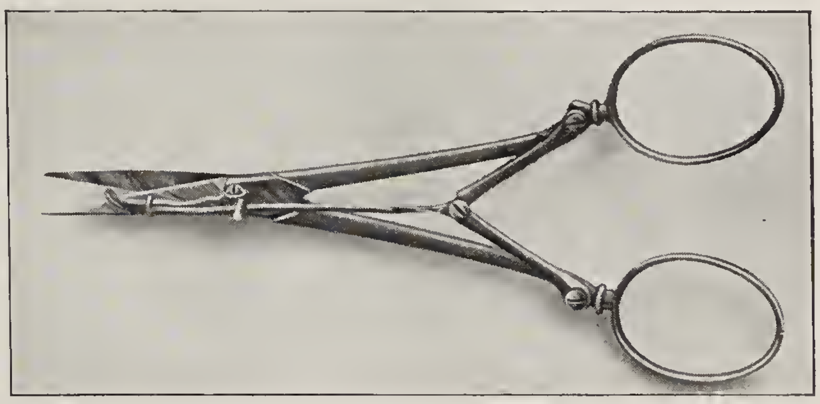


Fig. 117.—Combined Mouse-tooth Forceps and Scissors for Skin-grafting after Method of Reverdin.

Thiersch's Method.—This consists in shaving long strips of the thickness of only a portion of the skin from the outer surface of either the arm or the thigh, preferably the latter, by means of a razor, and transferring these directly to the surface prepared for their reception. It is applicable alike to chronic ulcerated surfaces and to defects left after the removal of large tumors, particularly those of the breast. In the case of the former, the granulating surface should be brought into as healthy a condition as possible. In the case of the latter all hemorrhage must be arrested before the grafts are placed in position. The grafts must be of uniform thickness and have even edges, in order that there may be no gaps between for cicatricial tissue to form. **Parallel incisions** marking the lateral boundaries of the strips to be taken may be made from one to two inches apart, according to the requirements of the case, these passing only partly through the skin. The skin is now put on the stretch. (Figs. 118 and 119.) Pressure by some hard substance on the skin surface just in advance of the razor sometimes answers a good purpose. In the case of the arm, the surgeon's hand encircling the parts will make sufficient tension. The strips are cut

by a sawing movement of the razor, held flatwise. The field of operation should be kept moistened with a sterilized normal salt solution; no antiseptics are used.

The grafts are applied at once to the defect or ulcerated surface, care being taken that their edges do not roll under, and are covered with strips of sterilized oiled silk protective arranged in "basket strapping" fashion, with narrow intervening spaces for drainage (Fig. 120). Gauze dressings wrung out of the sterilized normal salt solution are applied and this is again covered with protective or rubber tissue; a layer of cotton and a roller bandage complete the dressing.

Fig. 118.—McBurney's Skin-stretching Hooks.

The dressings should be changed in from one to three days. If any portions of the grafts have perished, they should be trimmed away with sharp scissors in order to prevent infection of the remainder. Moist dressings are to be reapplied at intervals of forty-eight hours until healing takes place.

The success of the method depends mainly on obtaining grafts of even thickness and with clean-cut edges, rendering the parts from which these are taken, as well as the surface to which they are to be applied, aseptic, and

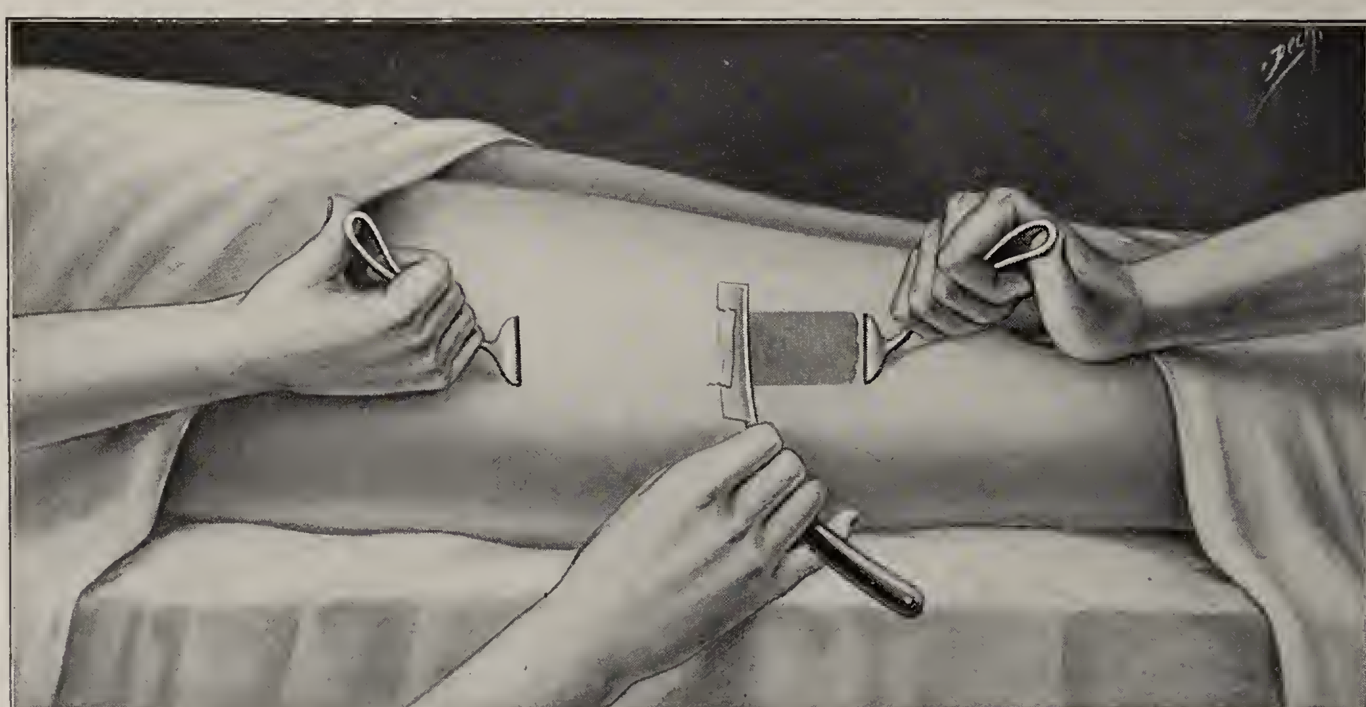


Fig. 119.—Cutting a Skin-graft.

securing firm contact between the surface of the grafts and that of the ulcer, with no blood between; finally, on the early removal of such portions of grafts as fail to take.

The **Ollier method** of skin grafting differs from that of Thiersch in that the former aims to obtain a graft as thick as possible without including the subcutaneous tissue, while the latter makes the graft as thin as possible. All fat must be carefully removed from its raw surface. Its area must be at least

one-sixth larger than the surface to be covered, and in adjusting it in place, its edges must be accurately coaptated to the raw edges of the defect. No sutures are employed. The parts are dressed with moist dressings.

The After-treatment of Plastic Operations.—An irrigating fluid should be employed which does not coagulate the albuminous substances on the surface of the flap or defect. A 0.6 per cent solution of sodium chlorid answers the purpose best. Dressing, as well as gauze sponge material employed about the operation, should be wrung out of the same. The site of the operation should be carefully covered in by narrow strips of oiled silk protective, arranged as in "basket-strapping" (page 332). Over this is placed a goodly supply of aseptic gauze, and the whole covered with sterilized cotton and held in place by a roller bandage. On redressing, after three to five days, care should be taken

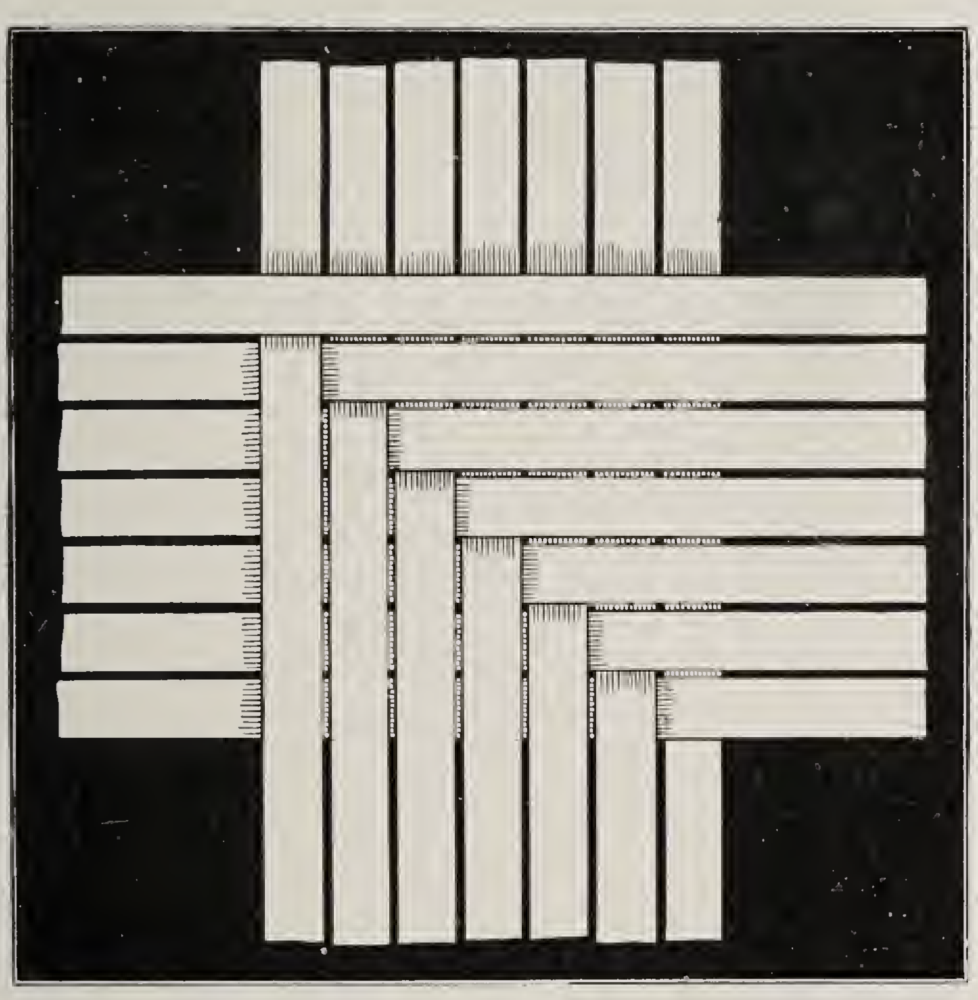


Fig. 120.—Basket Strapping Dressing for Skin-grafting.

not to disturb the transplanted portions of tissue. The moist dressing should be continued and changed every second or third day. False or cicatricial keloid, which sometimes develops between the flaps, is said to be prevented by keeping up moist dressings until the healing is completed (McBurney).

THE REMOVAL OF TUMORS OF THE SKIN

Those having a narrow base or pedicle, particularly when small or of but moderate size, are best removed by putting the pedicle or base on the stretch and severing with the curved scissors. Some **nevi pigmentosi** may be treated in the same manner. Cauterization of warts and nevi is now an obsolete procedure.

Congenital capillary and capillary venous tumors are best treated by extirpation with the knife. The hemorrhage requires special care in its

management. The dilated veins usually reach through the subcutaneous connective tissue to the fascia, and it is therefore best to carry the incisions directly to the latter structures. The vessels leading to the diseased portion should be grasped by the fingers of an assistant and held until secured by the hemostatic forceps.

Ligation of the base may be combined with extirpation. The employment of the ligature alone is objectionable on the score of excessive pain and sepsis. Small angiomas may be destroyed by means of the thermocautery, or the galvanocautery loop. The platinum wire of the latter is led around the base in the subcutaneous connective tissue as an encircling suture. Small angiomas also may be attacked by electrolysis. This is accomplished by passing needles, insulated for a greater or lesser distance, into the tumor in a direction parallel to the surface and attaching these to the poles of a galvanic battery, the current being allowed to pass through them; or one needle may be employed, the other pole of the battery being attached to a sponge electrode placed in the neighborhood. To save repeated puncture with a single needle, a number of these may be fastened to a handle (Fig. 121) to which is attached a wire connected with the battery.

Fig. 121.—Stevenson's Instrument for Electrolysis.

The method by the injection of water at a high temperature for the obliteration and cure of vascular non-malignant neoplasms consists of the injection of water at a temperature of from 190° to 212° F., or sufficiently hot to coagulate the blood and the albuminoids of the tissues (Wyeth). A metal syringe is employed and the amount of water used and the temperature are governed by the character and size of the growth, and by its situation. Capillary nevi, or "mothers' marks," should receive small injections under slight pressure and at a temperature not above 190° F. Care should be taken not to scald the skin. A slight blanching of the latter in the area of each injection suffices and is a signal in all cases to cease at once injecting in that area. The injections are repeated at intervals of a week, according to the effect produced. In cirsoid aneurism and large cavernous nevi the water should be kept at the boiling-point, and large quantities (up to five or six ounces in some instances) used. A general anesthetic is necessary. Peripheral compression should be used to prevent embolism.

Vaccination of an angioma is a very uncertain procedure; the injection by means of perchlorid of iron solution is mentioned only to be condemned.

Venous angiomas or **cavernous tumors** are best circumscribed by incision and are rapidly extirpated. **Varices** are treated of on page 100 and **cirsoid aneurism** on page 94.

Atheromatous cysts or wens may perforate the skin, either through a suppurative process or otherwise, **atheromatous fistulas** resulting. The suppurative form may result in epithelial carcinoma. In extirpating these cysts care should be taken to preserve the sac intact in order to facilitate its entire removal. A horseshoe-shaped incision should be made well beyond the

limits of the tumor, partially surrounding the same. By turning up the portion of skin inclosed in the incision as a flap to which the tumor is attached the entire growth may be dissected from the flap and the latter replaced.

Congenital dermoid cysts may be dealt with in the same manner. In these cases a deeply placed pedicle is often found containing the vessels of supply.

Lipomas are extirpated by two converging incisions (elliptic incision). In some localities, *e. g.*, the neck and shoulders, these growths cannot be distinctly defined and the removal must be more or less arbitrary. The simple character of these tumors should not impel the surgeon to relax his vigilance in the application of aseptic measures, for the reason that erysipelatous inflammation is particularly liable to follow their removal.

In **elephantiasis arabum** excision of the hypertrophic portions, when possible, is preferable to the long incision formerly employed. When the scrotum is the part attacked, extirpation may be indicated. Amputation should be reserved for cases in which an extensive and incurable ulceration is present, or suppuration of a large joint occurs.

Malignant Tumors of the Skin.—Three absolutely positive indications always exist and must be rigidly followed in operating for these growths: (1) The operation must be performed as early as possible; (2) the extirpation must be as complete as possible; (3) the next adjacent lymphatic glands, if it is possible to identify them, must be removed at the same operation.

As to the first: In cases of doubt it is better to remove an innocent tumor than to permit the development of advanced carcinoma. As to the second: Thorough extirpation demands the free use of the knife, rather than caustic applications. The most deplorable errors, as well as the most common on the part of the practitioner, consist in the occasional touching of commencing epithelioma of the skin with nitrate of silver. Should the prejudices of the patient prohibit the employment of the knife, the use of the Paquelin cautery offers the next best means at our command. Pastes of zinc chlorid, arsenic, etc., are occasionally successfully employed. A removal or destruction of all the diseased tissue, together with half an inch or more of surrounding healthy tissue, constitutes the only means of avoiding recurrence of the disease. As to the third: Unfortunately, when secondary glandular involvement is present in carcinoma, the prognosis is exceedingly unfavorable. Many of the diseased lymphatic glands are so deeply situated as to escape recognition and extirpation. Every swollen gland in the neighborhood should be removed. Diligent search should be made for diseased lymphatic glands deeply situated.

In late cases and in persistent regionary recurrences operative procedures of a purely palliative character are justifiable. There is a limit to these, however, particularly where great risk to life is involved. But curettage and energetic antiseptic treatment, including the use of the thermocautery, or of a 10 per cent solution of zinc chlorid, followed by dusting with iodoform to meet the indications of hemorrhage and sepsis, are almost always justifiable.

The above remarks apply likewise to other forms of malignant disease of the skin, particularly that exceedingly malignant form known as **melanotic sarcoma.**

OPERATIONS ON BLOOD-VESSELS

THE ARREST OF HEMORRHAGE

Hemorrhage is distinguished according to its source as arterial, venous, and capillary or parenchymatous. The methods employed to arrest hemorrhage are either **direct** or **indirect,** according as they act immediately at the place of bleeding, or through distant parts. The procedures are also classified as **provisional** and **definite.**

The importance of saving as much blood as possible during operative procedures is very generally recognized, not only for the immediate, but for the ultimate prognosis. On the completeness with which all bleeding is arrested before the wound is closed, as well as on the efficiency of the measures taken to prevent recurring and secondary hemorrhage, will depend, to a great extent, prompt healing of the wound and rapid recovery of the patient.

For spontaneous arrest of hemorrhage see page 87.

Provisional measures for the arrest of hemorrhage are indicated

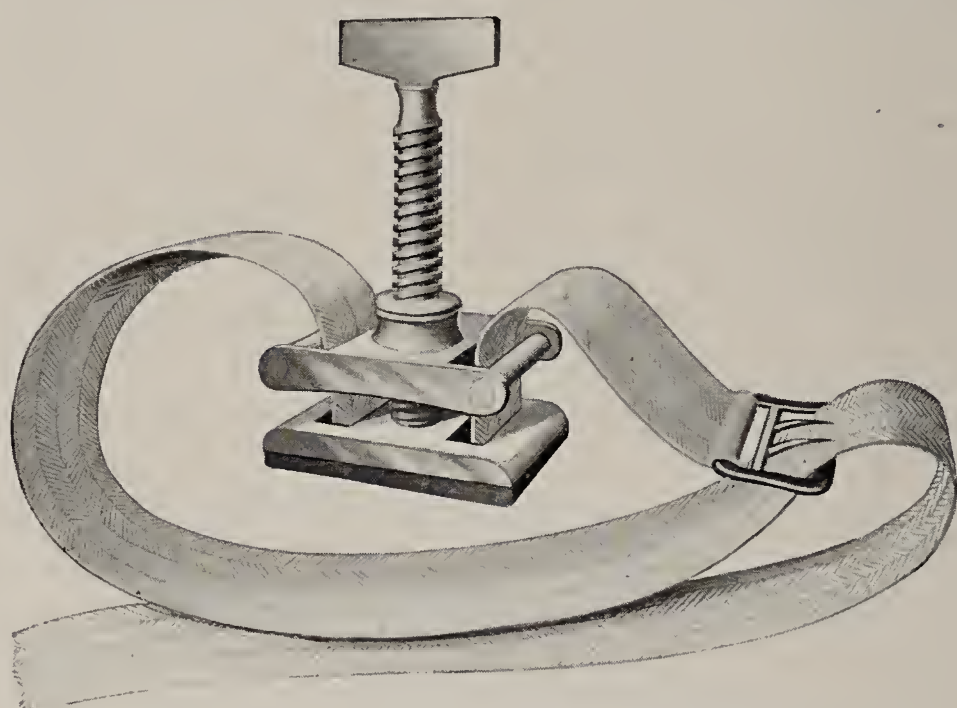


FIG. 122.—PETIT'S SCREW TOURNIQUET.

under circumstances where means and appliances for its definite arrest are not at hand, or where, if they are at hand, their application would consume valuable time and risk the patient's life. They consist in procedures having for their object the interruption of the blood-current between the heart and the bleeding point. This is accomplished by (1) **digital compression**; (2) **forced positions of joints**; (3) **pressure by means of specially contrived apparatus** (**arterial compressors,** or **tourniquets**).

In **digital compression** a point should be selected where the artery can be pressed against a bone. In the lower extremity the femoral artery can be readily pressed against the horizontal portion of the pubic bone just below Poupart's ligament. In the upper extremity the brachial artery can be pressed against the humerus along the inner margin of the biceps muscle. With the arm abducted, the axillary artery can be pressed against the head of the humerus. The common carotid artery may be pressed against the carotid tubercle (the anterior tubercle of the transverse process of the sixth cervical

vertebra). In this latter procedure, however, free anastomosis with the artery of the other side, as well as with the subclavian branches, very quickly restores the circulation beyond the point of pressure. The radial artery may be pressed against the radius and the posterior tibial against the inner surface of the os calcis. In thin individuals the aorta may be pressed against the lumbar vertebrae in hemorrhage from the internal iliac.

In forced positions of joints the arrest of hemorrhage may be accomplished without special apparatus and without anatomic knowledge. Extreme flexion of the elbow-joint and of the knee-joint will bring pressure to bear respectively on the brachial and popliteal arteries. Hyperextension of the hip-joint will bring the femoral artery to bear strongly against the horizontal ramus of the pubic bone so as to obstruct its lumen almost completely. The clavicle may be made to approach the first rib, so that pressure is brought on the subclavian artery, by extreme adduction of the arm to the anterior surface of the thorax, and at the same time the acromion is forcibly crowded down.

Fig. 123.—Spanish Windlass.

Pressure by Means of Specially Devised Apparatus.—The term "tourniquet" is now applied to all apparatus devised for the arrest of hemorrhage. The old-fashioned screw tourniquet (Fig. 122) is now employed only to fulfil special indications (arterial compressors designed for special classes of cases will be treated of in Regional Surgery). The Spanish windlass (Fig. 123) is of value in hemorrhage from the vessels of the extremities, from the fact that it may be readily improvised. A handkerchief is tied loosely around the limb and a stone or other hard object is placed over the vessel and beneath the handkerchief. A cane, bayonet, sword, scabbard, drumstick or similar object may be employed to twist the handkerchief until the bleeding is arrested. The pressure is brought to bear on veins, nerves, and lymphatics as well as on the artery, and for this reason the use of the windlass should not be long continued.

Bloodless Operations by means of Esmarch's Elastic Compression.—This is applied principally to the extremities and is intended to secure

a completely exsanguine condition of the portion to be operated on. The limb is elevated for a few minutes in order to empty the large venous channels into those of the trunk and is then tightly bandaged in a spiral manner from below upward by means of a rubber bandage. The turns of the bandage, with the exception of the first two, should overlap each other but slightly (Fig. 124). The bandage should be continued some distance beyond the point of proposed

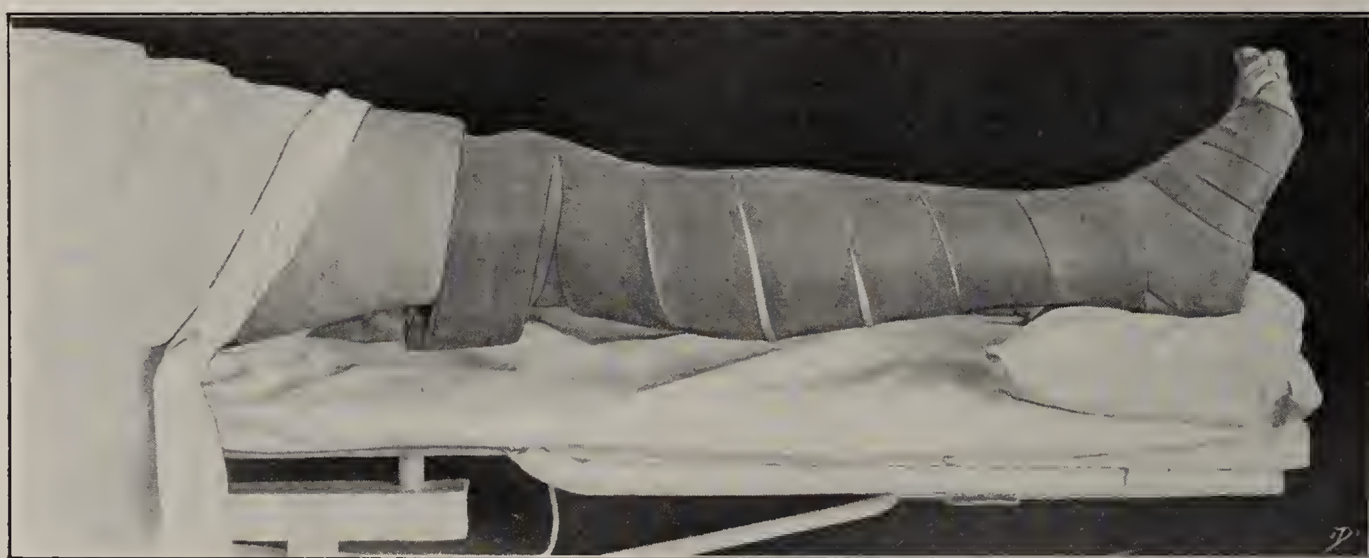


Fig. 124.—Esmarch's Bandage Applied.
Showing method of application without overlapping. The last three turns serve as a tourniquet.

operation. Here a few circular turns of the bandage are made, these are lifted forcibly away from the limb and the remaining portion of the roller forced beneath them at the site of the main vessel of the limb. The spiral turns are now unwound, at a point commencing from below (Fig. 125). A tourniquet consisting of a narrow band of rubber with hook and chain fastening is

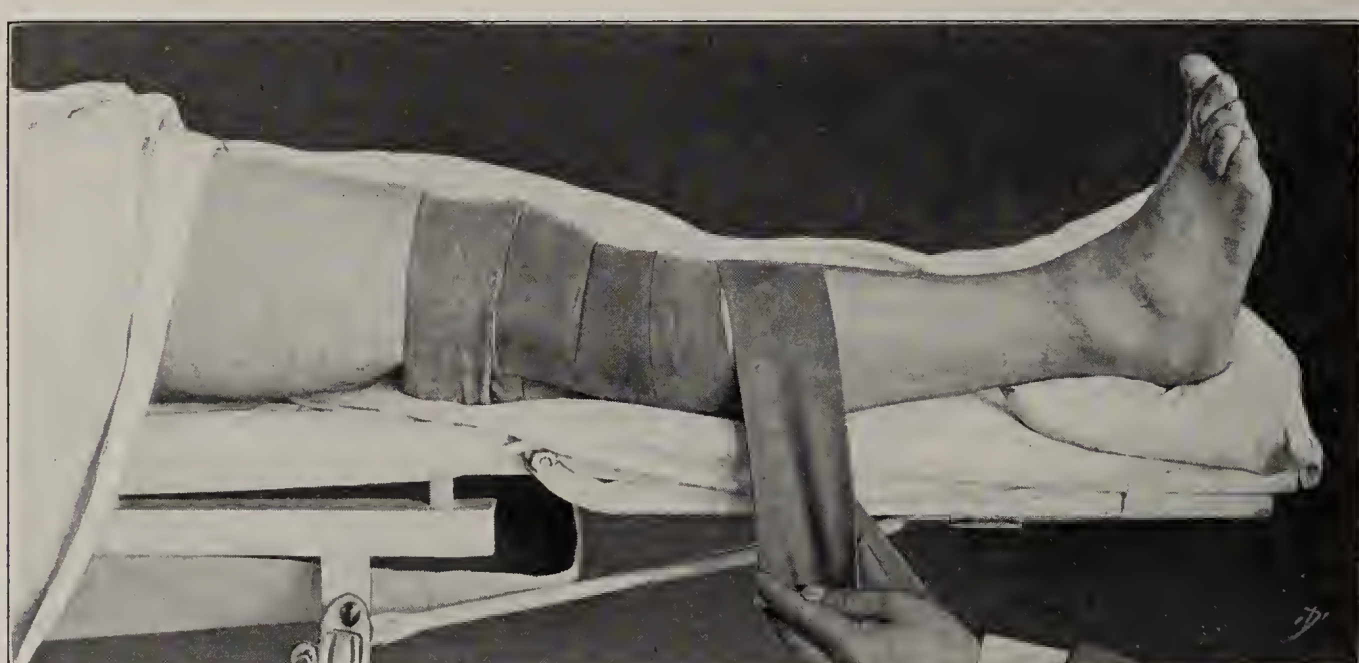


Fig. 125.—Esmarch's Bandage, Showing Ease of Removal of the Bandage.

sometimes employed to secure the vessels immediately above the termination of the bandage before removing the latter. Or a hard roller of muslin may be laid over the vessel and secured by a few turns of the rubber bandage (Fig. 126).

The procedure serves only a temporary purpose. As soon as the constricting band is removed, not only does the blood flow from the larger vessels, but

there is a relatively greater amount of parenchymatous oozing. This is due to a paralysis of the muscular apparatus of the vessels in consequence of the compression, which is complete and continued in proportion to the length of time the compression is kept up. It may therefore happen that the patient loses as much blood as would have been lost if no preliminary application of the rubber bands had been made. Paralysis of an extremity has also been charged to the use of Esmarch's bandage from compression of nerve-trunks, as well as sloughing of flaps in amputation cases.

In spite of the alleged disadvantages of Esmarch's procedure it is of great value. It permits rapid operative work, particularly in sequestrotomies, resections, amputations, etc. Special care should be exercised in its application. If the constricting band is applied too loosely, the venous return flow is interfered with, while the supply of blood is not interrupted; hence a large amount of venous blood may be lost. On the other hand, a too tight constriction endangers the nerve-trunks. In case of the removal of a large portion of the body, such as a limb, the saving of blood by forcing it from the

Fig. 126.—Esmarch's Bandage, showing Hard Roller in Position over the Vessel and Secured by the Last Few Turns of the Bandage.
The roll in front is the loose bandage unwound from the limb, gathered in a roll, and placed for convenience of disposition beneath a few loosely applied turns.

limb to the trunk and into the rest of the circulation constitutes of itself a very great advantage.

All vessels that can be identified should be ligated before the removal of the constricting band. The application of compresses wrung out of hot water serves to check the capillary hemorrhage.

The presence of malignant disease, putrefaction, or suppurative conditions in the limb is a contraindication to the use of the Esmarch compression bandage. Infectious material may be forced into the lymph-vessels in this manner and distributed over the entire body.

Prophylactic Hemostasis.—This may be obtained by (1) digital compression by a trained assistant; (2) tourniquets and compressors applied from the surface; (3) temporary compression through an open wound after exposure of the vessel, by means of encircling tapes or bands, or instruments specially devised for the purpose (Crile); (4) preliminary ligation of the main arterial trunk (see page 345).

Permanent Arrest of Arterial Hemorrhage.—This is accomplished by **forcipressure,** followed either by torsion or by application of **the ligature.** Under certain circumstances it may be necessary to rely entirely on the forceps.

The habits and fancy of the operator will usually govern his selection of artery clamps or hemostatic forceps. The ring-handle instrument of Pean and its modifications are employed by most surgeons (Fig. 127), while the slide catch or torsion forceps are preferred by others. In any case the ends of the blades or jaws should be so shaped as to permit the ready sliding of the loop of the ligature therefrom. The forceps should be loosened and removed by an assistant before the first portion of the knot is fully tightened, in order that the

FIG. 127.—VARIETIES OF HEMOSTATIC FORCEPS.

constricted portion of the vessel may adapt itself in shape to the final grasp of the ligature. In case of emergency a tenaculum may be employed to lift the bleeding vessel away from the tissues. If this method is used, ligation of the vessel must at once follow. If the hemostatic forceps are employed, these may be left until the close of the operation.

The knot may be the usual square or reef knot; a "granny knot" with three turns serves equally as well. In ligation in continuity the "stay knot" of Ballance and Edmunds is employed (Fig. 128).

Ligature Material.—Since the introduction of aseptic surgery catgut has almost entirely replaced silk as a ligature material. Both ends are cut short and buried in the tissues. The ligature material is destroyed if the wound

follows an aseptic course, living tissue being proliferated into the dead but aseptic substance of the catgut. If septic conditions supervene, the ligature material as well as the portions of tissue constricted may be cast off. Silk, if only the smallest or finest sizes are used, and if this is made thoroughly aseptic, may, if it is specially desirable to employ it as a ligature material, also be cut short and left in the tissues. If primary union is obtained its presence in the tissues may do no harm (Kocher, Halsted). Nevertheless it remains as a foreign body, and hence, as a ligature material, it falls short of the requirements of ideal surgery.

Torsion may be sometimes employed. It is accomplished by grasping the vessel by two forceps and twisting it several times on its own axis between the forceps. The lumen is closed by a rolling together of the intima. The method is applicable only to the smaller vessels and has been but little used since the introduction of absorbable ligatures.

Acupressure consists of pressure exercised on the vessel by means of a long needle passed through the tissues. The procedure has practically fallen into disuse. The **suture ligature, or circumsuture,** is employed if the wounded vessel is situated in tissues where it is inaccessible, as, for instance, when a vein is wounded by the puncture of a needle in suturing a wound, or if it is situated in tissues from which the points of the artery forceps repeatedly slip off. A full curved needle threaded with catgut is used. This is passed through the tissues in which the bleeding vessel is situated and at a short distance from the latter, in such a manner as completely to circumscribe the vessel. It is then drawn tightly and secured by a knot.

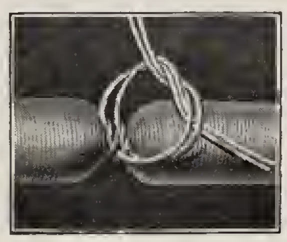


Fig. 128.—The Stay-knot of Ballance and Edmunds.

Suture of Arteries.—In the case of small wounds of large arteries, in which ligation of the vessel is contraindicated, the opening in the latter may be sutured. A round intestinal needle and fine chromicized catgut should be used. All the coats of the vessel should be included in the sutures. A second row of sutures, including the sheath and the overlying tissues, is to be applied. During the operation the wounded portion of the vessel should be kept free from blood by digital compression. The contraindications to suture of arteries are (1) large transverse wounds of the vessel; (2) lacerated wounds; (3) contused wounds, *e. g.*, gunshot wounds. An atheromatous condition of the vessel does not necessarily furnish a contraindication to the procedure.

Suture of the arteries is not likely to find favor among practical surgeons for the following reasons: (1) Circumstances rarely arise demanding its employment to the exclusion of other means of securing hemostasis; (2) there is a not unfounded fear of thrombus at the seat of injury; (3) the dangers of aneurism due to subsequent yielding of the scar in the vessel are not to be lost sight of.

Arterial Invagination.—In this operation the proximal end of the artery is invaginated into the distal end, where it is secured by firm catgut sutures (J. B. Murphy). Temporary occlusion of the vessel is first obtained. The distal end of the artery is incised longitudinally for a short distance and the sutures are preliminarily applied to facilitate the invagination (Fig. 129). The method may be used in cases in which arterial suture is contraindicated and ligation in continuity undesirable.

Arrest of Parenchymatous Hemorrhage.—Simple pressure of the wound surface by accurate suturing and the application of dressing usually suffice to arrest this form of bleeding. Other methods consist of the application of compresses wrung out of hot water, or, better still, hot saline solution. Ice, ice-water, or the ethyl chlorid spray should never be used in hemorrhage complicated by shock. The **actual cautery** long antedated the use of almost all hemostatics. When this is employed, it should be used at a **red** rather than a **white heat.** The thermocautery (page 316) or the galvanocautery (page 315) has now almost entirely replaced the cautery irons of the older surgeons.

Tamponade.—Continuous oozing of blood from large wound surfaces, and even bleeding from vessels of considerable size, may be arrested by the application of an antiseptic tampon. The tampon should be of one strip, rather than of a number of small pieces, in order to avoid overlooking one or more of the latter on removal. If no contraindication to its use exists, *e. g.*, in the case of children, old persons, and those that are the subject of renal disease, iodoform gauze may be freely used. Otherwise zinc oxid gauze, or even plain sterile gauze, is to be employed. If blood finds its way to the surface the packing is to be removed and replaced by fresh gauze. Unless some indication arises for its removal it is to be allowed to remain forty-eight hours, at the end

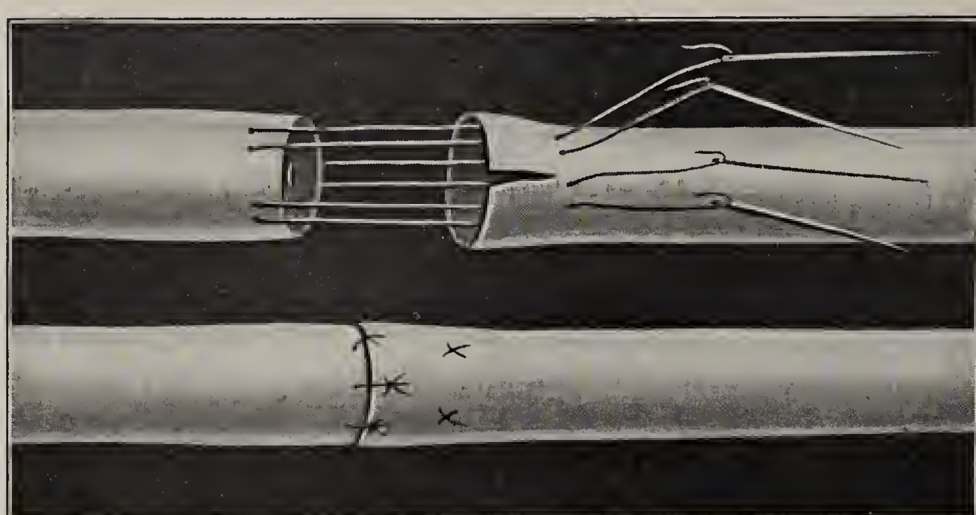


FIG. 129.—MURPHY'S METHOD OF ARTERIAL INVAGINATION.

of which time, in the majority of cases, the bleeding vessel will have become obliterated. If oozing persists, the bleeding surface may be moistened for a short time with adrenalin chlorid solution, 1:1000, and repacked.

If the bleeding space is large a "chemise tampon" may be employed. This consists of a spread out square of iodoform gauze of sufficient size, to the center of which a silk ligature is secured to facilitate its removal. This is spread out on the wound surface and the pouch thus formed is tightly packed with gauze. The silk ligature is brought outside and the projecting ends of the pouch gathered up and secured by a tape or narrow strip of gauze.

The Graduated Compress.—Where the bleeding occurs from a definite area the tampon is applied in the shape of an inverted cone, the apex of which is made to rest on the bleeding point. **Deep suturing** by means of the buried catgut suture is sometimes of use in the arrest of otherwise intractable bleeding. A round needle should be employed in order not to provoke further hemorrhage, and several layers of sutures may be applied, if necessary, care being taken to include any bleeding points discoverable.

Styptics.—Of the numerous styptics formerly employed, the solution of the sesquichlorid of iron is almost the only one now used. Even this is more often abused than rationally employed. The iron salt incorporated in dry cotton is to be preferred to the moist application.

The active principle of the suprarenal capsule (adrenalin) is a valuable local hemostatic agent. It is employed in the shape of adrenalin chlorid solution, 1 : 1000. Care should be exercised in its use, since the blanching of the tissues is marked and may become excessive, leading to sloughing.

Oil of turpentin is useful as a styptic after excision of the tonsils. **Ferripyrin,** a combination of chlorid of iron and antipyrin, in 20 per cent solution has recently been used with success in epistaxis (Jurasz).

Antipyrin has been found to possess valuable hemostatic as well as antiseptic properties (Park). It should be used in 5 per cent solution. Gauze wrung out of this solution may be bandaged on bleeding surfaces or packed in cavities such as the nasal cavity. It may also be used in the form of spray with an atomizer.

Hemorrhage in Hemophiliacs or "Bleeders."—The surgeon is occasionally called upon to operate on patients who are the subjects of hemophilia, as well as to arrest hemorrhage in these from wounds accidentally inflicted. In addition to the styptic measures already mentioned, inhalations of carbon dioxid gas and the internal administration of calcium chlorid in from 30- to 60-grain doses four or five times a day are to be employed. Saline infusion is contraindicated, but copious rectal enemas of hot saline solution should be used. When the bleeding has been arrested the patient should be placed on a nutritious diet and preparations of iron, such as Blaud's mass, or the tincture of the chlorid should be given. Operations on hemophiliacs should be avoided as much as possible, and when not absolutely necessary they should be postponed for a few days to permit the preliminary administration of calcium chlorid.

Arrest of Venous Hemorrhage.—Bleeding from veins as well as from arteries occurs in the larger operations. The dread formerly entertained of the occurrence of suppurative phlebitis after ligation of large veins has entirely given way to the confidence felt in aseptic and antiseptic measures. Whenever venous channels are opened during operation, they may be ligated with the same confidence as in the case of arteries.

The necessity for ligation of veins arises more frequently in operations on the lower extremity than elsewhere, owing to the fact that numerous varices are here present; in amputations particularly, dilated veins are found in the muscular structures. Simple pressure in cases of superficial veins, when wounded, will generally arrest the hemorrhage, *e. g.*, rupture of varicose veins. A compress and a well applied bandage usually fulfil the indications in these cases.

Air Embolism.—In the anterior region of the neck special dangers may arise from injuries to the veins, particularly to the external jugular. This danger refers to the aspiration of air. This may occur likewise in wounds of the internal jugular, the superior vena cava, the innominate, the subclavian and the axillary veins. The wide-open mouths of these vessels and the bloodstream flowing toward the heart favor the entrance of air through a wound in the vein, when an inspiration occurs. A peculiar gurgling or hissing sound

is heard as the air rushes in. The symptoms will depend on the amount of air which enters. If small in quantity, no harm beyond labored breathing and rapid heart action may result. If a large quantity enters, death may occur at once, the air collecting in the right side of the heart and preventing the contraction of the right ventricle. The accident occurs more frequently in surgical operations than under other circumstances. The **treatment** consists in instant compression on the cardiac side of the injured vein and the flooding of the field of operation with sterile water until the vessel is secured. Inhalations of oxygen should be given, compression should be made on the chest wall to favor forced expiratory movements, electricity should be applied over the heart, and the limbs should be bandaged.

In operations about the lower and anterior part of the neck a competent assistant should stand ready to make compression between the point where a large vein is endangered and the heart, in order that aspiration of air may be avoided in case the vein is wounded. When large venous channels are discovered to be involved in the neoplasm during its removal, these should be divided between two ligatures preliminarily applied.

Lateral Ligation of Veins.—Small lateral injuries of veins, or an injury of a small vein at the point where it joins a main channel, may require the application of a lateral ligature. Under aseptic conditions small wounds of the largest vein may be dealt with in this manner. Under these circumstances the repair takes place without thrombus and the lumen of the vein remains patent. The wound in the wall of the vein is grasped with a hemostatic forceps and tied. Large wounds of the veins, in cases in which it is undesirable to ligate the latter, are best dealt with by suturing. In the case of a deep and inaccessible vein the hemostatic forceps may be permitted to remain *in situ* for several days (**forcipressure**).

Suture of Veins.—This operation is particularly indicated in wounds of large veins. The wounded portion of the vein is isolated by temporarily constricting it on each side. Sutures of silk or fine chromicized catgut are employed. If the latter material is used a second row of perivascular sutures is applied (Senn). Approximation of the intima is not essential to success (Schede). Silk sutures, when used, are always cast off in a direction away from the lumen of the vessel. The dangers of thrombus formation from this cause are therefore but slight.

Complete transverse separation of large veins requires that both ends be ligated.

LIGATION OF ARTERIES IN CONTINUITY

Indications.—The indications for ligation in continuity are (1) those arising from injury; (2) those arising from inflammatory processes; (3) those arising from tumor formations. In all procedures except that of Brasdor, the ligature is applied between the heart and the point of injury or disease, the blood-supply of the part being thus restricted. Complete arrest of blood-supply is prevented by the collateral circulation.

In case of injury (punctured wounds, gunshot wounds, and contusion of arteries) the ligature is to be placed as near as possible to the point of injury, and above and below the latter. If necessary, the wound of the soft parts is to be enlarged to accomplish this, but when this can be accomplished only with great

difficulty and the case is urgent, ligation at a distance from the bleeding point is indicated. In localities in which the collateral circulation is rapidly established, ligation in continuity may be followed by ligation at the point of injury.

Arterial secondary hemorrhage furnishes an indication for ligation in continuity. Secondary hemorrhage rarely occurs under aseptic conditions. It is generally due to either contusion of the arterial coats, these subsequently giving way, or septic inflammatory changes in the vessel or surrounding parts, or both. It is also known as "septic after-hemorrhage." It is to be distinguished from **recurring hemorrhage** which occurs within five or six hours after the injury, instead of as many days. In recurring hemorrhage the wound is to be reopened and the source of the bleeding sought. In septic after-hemorrhage, however, the condition of the tissues at the site of the original wound is such as to preclude, as a rule, a search for the bleeding point. The vessel must be ligated at a distance. Ligation in continuity is also indicated in certain cases of traumatic aneurism (*vide infra*).

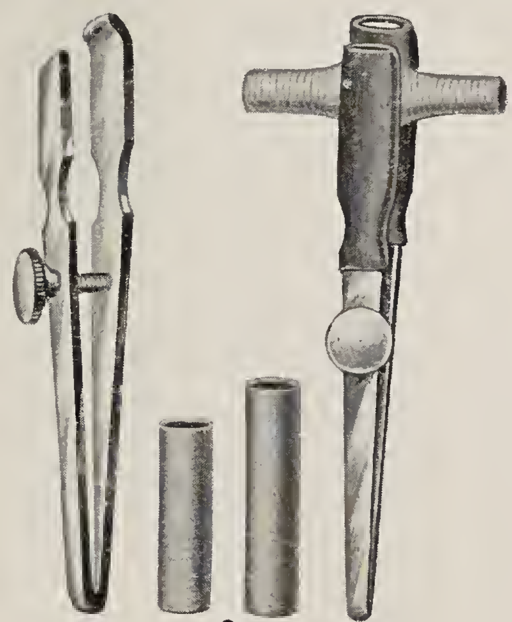


Fig. 130.—1, Crile's Clamp; 2, Rubber Tubing for Slipping over the Ends of the Clamps; 3, Clamp Applied to Artery.

Prophylactic ligation in continuity is indicated where an operative procedure is about to be instituted, in which it is more than likely that the arterial trunk must be divided. This may likewise be employed to prevent great loss of blood during the operation (extirpation of tongue, resection of the superior maxillary bone, etc.). Exposure of the vessel, and the placing of a ligature in position ready to be tightened in case of emergency, may also be practised.

Provisional arrest of the blood-supply of parts involved in proposed operations by temporary occlusion of the main trunk is of value at times. The best instrument for this purpose, the jaws of which should be guarded by rubber, is that devised by Crile, of Cleveland (Fig. 130). In the absence of this, a traction loop or a piece of tape passed about the vessel with the ends carefully twisted and clamped may be used. Even the slightest injury to the vessel must be avoided lest coagulation of the blood take place, the resulting clot being subsequently displaced and producing serious disturbances, particularly in the case of the carotid arteries. From the theoretic standpoint, and in the absence of sufficient operative experience to confirm the experimental observations made, the propriety of applying the method in the last-named situation is questionable.

Ligation in Continuity for Aneurism.—This is indicated by functional disturbances due to the presence of the tumor, growth of the latter with attenuation of its walls, and threatened spontaneous rupture and consequent fatal hemorrhage.

Ligation of the trunk above and below the sac and extirpation of the latter, the old operation of Antyllus, is the simplest method of treating aneurism. When the aneurism occupies the greater portion of the artery, the method is not applicable. Even after successful ligation above and below the aneurism difficulties may be met with in extirpation of the sac. Under these circum-

stances large branches may exist in the sac and fatal hemorrhage follow the attempt to remove the latter.

Ligation in continuity between the aneurism and the heart, the operation of Hunter, is the best known and most commonly practised of the operations for the cure of this disease. The retardation of the flow of blood in the sac leads to coagulation, and obliteration of the sac follows. This operation is successful in a certain proportion of cases. If the collateral circulation is established before obliteration of the aneurismal sac occurs, pulsation returns after some days. On the other hand, sudden interruption of the blood-current, particularly in elderly persons with endarteritis (see page 93), may lead to gangrene of the extremity.

Peripheral Ligation.—Where the central portion of the artery is not accessible and Hunter's operation cannot be performed, peripheral ligation may

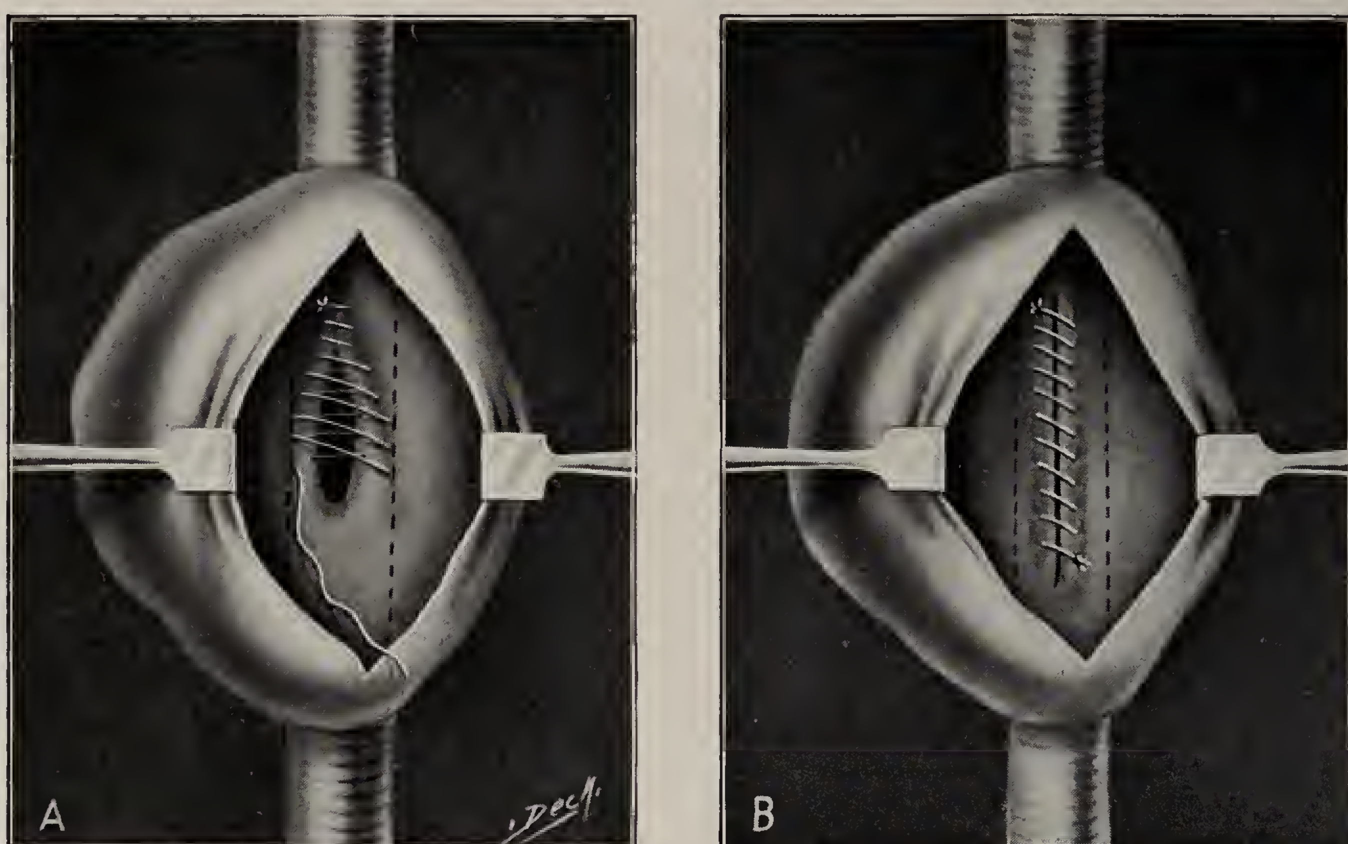


Fig. 131.—Matas's Operation for the Cure of Aneurism.
A, Showing the process of obliteration of the orifices of the aneurismal sac in a sacculated aneurism; B, the obliteration of the orifice completed.

be resorted to (Brasdor). It is used almost exclusively for the cure of aneurism of the innominate artery. The ligature is applied to either the right common carotid or the subclavian. As no branches are given off from this point of the aneurism, the formation of a thrombus advancing from the site of ligation will lead to obliteration of the sac.

Incision of the sac and subsequent ligation constitute a very bold procedure. The index-finger seeks the point of ingress of the blood and is made to act as a plug to the vessel, being withdrawn only at the moment of drawing a ligature taut about the artery. It is rarely indicated except in those cases of aneurism of the external iliac in which the tumor reaches to the common iliac and precludes the use of the operation of Hunter. It is too dangerous for general application.

Matas's Method of Arteriorrhaphy for the Radical Cure of Aneurism.—In this operation the sac is obliterated by a plastic procedure and the com-

munication between it and the artery closed, while at the same time an attempt is made to preserve the lumen of the artery.

The steps of the operation include (1) prophylactic hemostasis, which may be accomplished by means of a Crile's clamp or a silk traction loop, applied, when necessary, to the distal as well as to the proximal pole of the aneurism, as, for instance, in aneurisms in the cervical region; (2) exposure of the sac by a free incision parallel to the long axis of the tumor; (3) opening of the sac and evacuation of its contents; (4) closure of the arterial orifice or orifices by means of sutures so placed as to effect broad approximation of the serous surfaces of the margins of the openings; (5) removal of the clamp or constricting loop and test of the sutures; (6) obliteration of the aneurismal sac.

In the case of a sacculated aneurism the operation is comparatively simple. The orifice of communication between the artery and the sac is closed either by interrupted sutures or by a continuous suture of chromicized catgut (Fig. 131).

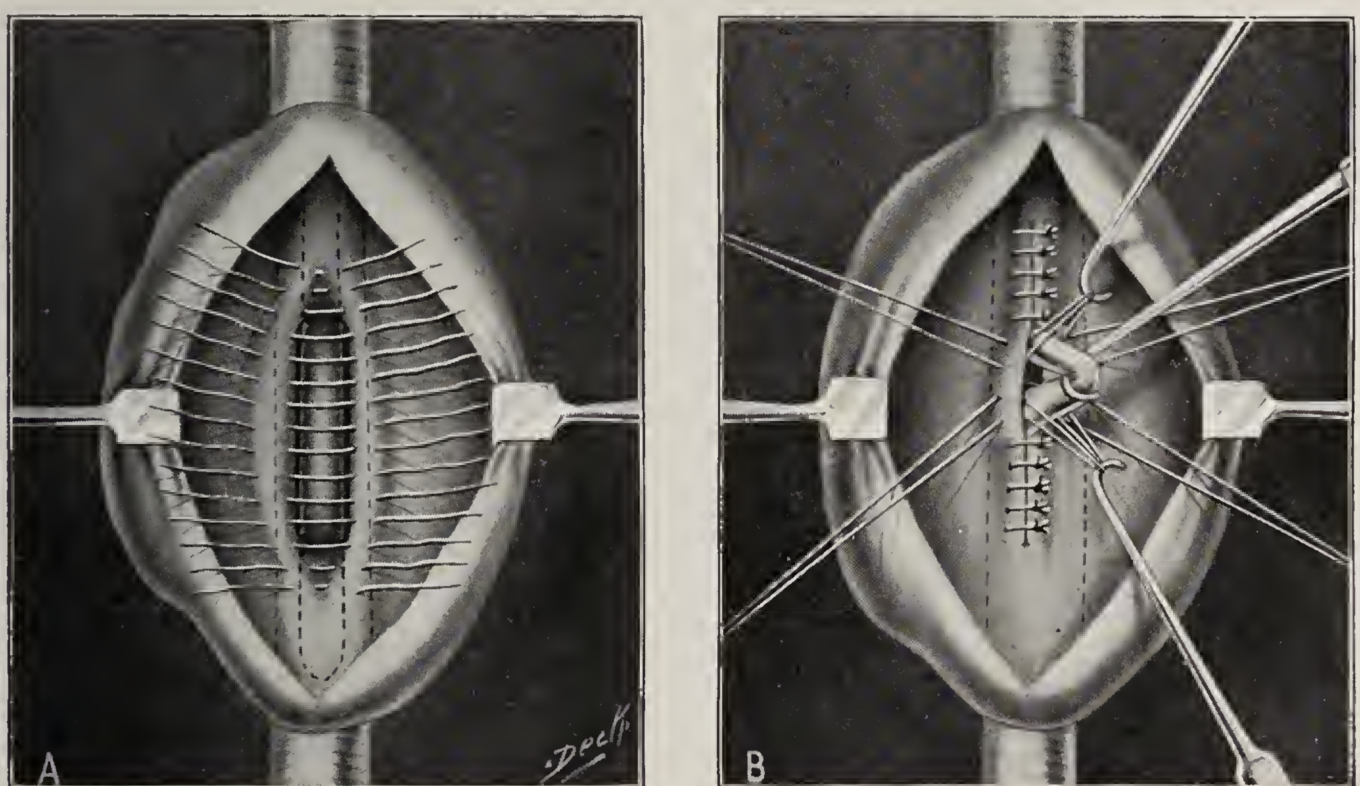


Fig. 132.—Matas's Operation for the Cure of Aneurism.
A, Showing the method of closing the orifices and constructing a new arterial channel in a fusiform aneurism; B, removal of the guide.

In fusiform aneurisms the procedure is somewhat more complicated. Here two large openings are present, the space between them representing the continuation of the floor of the parent artery. This space must be preserved, if possible, in order to aid in the construction of a new arterial channel. This is effected, where the flexible character of the sac will permit, by lifting two lateral folds of the sac and bringing them together by suture over a soft rubber guide, in the same manner as that adopted in Witzel's method of gastrostomy. The sutures are all placed while the guide (a soft rubber catheter of proper size) is in position (Fig. 132, A). The sutures are all tied with the exception of the two middle ones. These are drawn to one side and the catheter withdrawn (Fig. 132, B). The remaining sutures are now tied. Where the condition of the vessel walls will not permit the lifting of these to form lateral folds for suturing over a guide, as is not infrequently the case in aneu-

risms of pathologic origin, the orifices are closed by one or more tiers of sutures extending along the space representing the floor of the parent vessel and including both openings (Fig. 133).

After all of these procedures obliteration of the remaining portion of the cavity of the aneurismal sac is effected by approximating its walls by successive layers of sutures. The skin edges are then sutured and the dressings applied in such a manner as to fill the hollow on the surface left by the obliteration of the aneurismal sac.

In the after-treatment of all cases of obliteration of the main vessel of supply of an extremity the latter should be kept elevated to favor the return circulation and the temperature maintained by loosely bandaging with cotton batting and by applying artificial heat.

Other Methods of Treating Aneurism.—**Digital and instrumental compression** may be applied whenever the position of the aneurism permits the application. These methods are devoid of danger but excessively painful. To be effective the compression must be kept up for several days. Disappearance of pulsation and induration of the sac are the indications for its cessation. In case of digital compression relays of assistants are necessary. In instrumental compression the point of pressure must be occasionally changed. These are limited in their application, but in individual cases have given favorable results, particularly in the lower extremities. Few patients, however, have sufficient fortitude to endure the pain of their application. To assist this, hypodermic injections of morphin may be given.

Fig. 133.—Matas's Operation for the Cure of Aneurism.
Showing the orifices in the aneurismal sac in process of obliteration by suturing.

Chemical means calculated to bring about coagulation of the blood have been recommended. These, as, for instance, the injection of the solution of the sesquichlorid of iron into the sac, cannot be too strongly condemned.

Galvanopuncture consisting of the introduction of two fine needles as electrodes into the sac, and the coagulation of the blood by the passage of the galvanic current, as well as **acupuncture,** or the introduction of several needles into the sac, the needles remaining there for several hours in order to favor coagulation, has not been sufficiently long on trial to determine its advantages or dangers.

The introduction of foreign bodies into the cavity of the aneurism in order that the blood may coagulate around them has been recommended. For this purpose horsehair, catgut, and fine silver steel and copper wire have been employed. A number of yards of the material is introduced through a cannula (Moore). The wire after insertion may be connected with the anode of a galvanic battery (Corradi). There are two dangers to be apprehended from this procedure: (1) fatal hemorrhage may result from the puncture by

the cannula; (2) at the very beginning of the operation small clots may be swept away, and, in the shape of emboli, produce disturbances at a distance. Nevertheless the method is worthy of trial in inoperable cases.

The method of "**needling**" (Macewen) aims at the formation of a white thrombus on the inner surface of the sac. Long steel needles are introduced and gently manipulated so as to produce irritation of the entire lining. Several needles may be used at each sitting and the operation may be repeated until the thickening of the walls of the sac is evident.

Injections of ergot in cases of aneurism in the manner recommended in varices has been suggested (Langenbeck). The aqueous solution is injected by means of a hypodermic syringe around the outside of the wall of the sac. The ergot produces contraction of the muscular apparatus of the vessel. The method is applicable only in the earliest stage of the disease; as the latter progresses, the muscular fibers disappear.

Ligation in continuity in the treatment of neoplasms has not been very successful. In the case of the external carotid the addition of excision of the branches of the vessel on both sides (Dawbarn) promises to become a valuable resource in the treatment of malignant disease occurring in the area of supply of this vessel. The lingual arteries have been tied in carcinoma of the tongue (Dumarquay).

Ligation of the femoral artery has been employed in **elephantiasis arabum** (Carnochan). Hueter's suggestion of ligature of the external iliac in the same class of cases has likewise been followed. The rationale of the method is not clear. In a young man in whom I ligated the external iliac for elephantiasis arabum affecting but one extremity the method proved successful. After twelve years the patient still remains free from the disease.

Methods and General Technic of Ligation in Continuity.—The selection of the proper site for placing the ligature was formerly considered of the greatest importance. It was deemed necessary, in order to secure a long coagulum, to place the ligature as far as possible from a branch of the vessel as was consistent with the purpose for which the ligature was employed. The occurrence of suppuration, almost a necessary sequence of the operation and an accompaniment of the process of separation of the ligature in preaseptic days, in the case of a short coagulum was not infrequently followed by secondary hemorrhage and the necessity for a repetition of the ligation. These precautions are superfluous when the aseptic ligature and aseptic wound treatment are employed. Under these circumstances the size of the thrombus is of but little importance.

In addition to the requisite anatomic knowledge, it will be found useful to identify the vessel by its pulsation whenever possible. It is likewise necessary before applying the ligature to make digital compression at the point at which the occlusion is intended to be made. If pulsation ceases in the area intended to be deprived of supply, the operation is to be proceeded with; otherwise not.

In making the necessary incision for ligation of the vessel, care must be taken not to draw the skin away from the line of the vessel to one or the other side. The incision, as a rule, is made parallel to the long axis of the vessel, though there are several exceptions to this rule (see Regional Surgery). The skin, subcutaneous connective tissue, and fascia are separated by the incision, the different structures being steadied by the anatomic forceps. In making the dissection, the muscular structures should be spared as much as possible.

In reaching the sheath the exact location of the vessel is ascertained by feeling for its pulsation with the point of the finger. In case pulsation is absent the artery is identified as a flat cord with a solid feel; the vein which accompanies it appears soft, while the nerve has a more solid but roundish feel. The relation which these bear to each other must also be borne in mind. In order to avoid injury to the vessel in opening the sheath the latter is grasped by the anatomic forceps, lifted away from the vessel, and opened by an incision parallel to the arterial wall.

The sheath is now separated from the vessel by means of the blunt end of the scalpel or a probe, each edge of the incision being steadied in turn by the anatomic forceps for that purpose. This being accomplished a blunt aneurism needle (Fig. 134) armed with a double ligature is passed around the vessel. A bent probe with an eye may be made to answer the purpose. The instrument should always be passed from the direction of the vein, in order to avoid injury to the latter. The arterial wall must not be grasped by the forceps, else injury to this may result. It is well to ligate at two points and divide the artery between these; the gaping lumen of the vessel will positively identify it.

a b c

Fig. 134.—Aneurism Needles. *a*, Straight; *b*, left; *c*, right.

In tying the ligature it is not always necessary to apply a surgical knot. The ordinary flat knot will answer. The turns of the knot are directed to the arterial wall by the tips of the index-fingers. The first turn is to be drawn moderately tight; it is not necessary that the operator should feel the giving way of the middle and inner coats of the vessel, as was formerly taught. The second turn should be only sufficiently drawn to secure the first turn against slipping. A third turn affords additional security.

For the larger vessels sterilized silk is preferred to catgut by some surgeons, through fear of a too early loosening of the latter. Catgut boiled in alcohol (page 53) will last sufficiently long for any vessel.

The ends of the ligature are cut off about one-eighth of an inch from the knot. The wound is sutured in its entire length and dressed aseptically.

OPERATIONS ON VEINS

Lateral ligation of veins has been already described. Transverse ligation in continuity of large veins is somewhat more difficult than in the case of arteries. With care, however, it may be accomplished. Smaller veins may be ligated as readily as arteries.

Ligation in continuity of veins is sometimes indicated and practised in cases of varices. Ligation of the internal saphenous vein (Trendelenburg) just below the point where the superficial circumflex iliac, the superficial epigastric, and the superficial pudic veins join the vessel near the saphenous opening, and ligation of the external saphenous in the middle line of the posterior aspect of the left leg just before this vessel pierces the deep fascia to join the popliteal vein, are employed for the cure of varicose veins of the thigh and leg. When the superficial epigastric and superficial pudic veins are involved these vessels should be ligated separately.

Multiple Ligation.—The multiple ligation of veins communicating with varices, with formal excision of the latter, is often practised with advantage. **Avulsion of the vein,** *i. e.,* its removal by traction after its ligation through two small openings placed some distance apart, is sometimes practicable. The so-called "garter-operation" consists of a circular incision of the limb which divides all the superficial structures, including the veins, which latter are ligated at both divided ends. The method, if employed at all, should be reserved for the most aggravated and intractable cases.

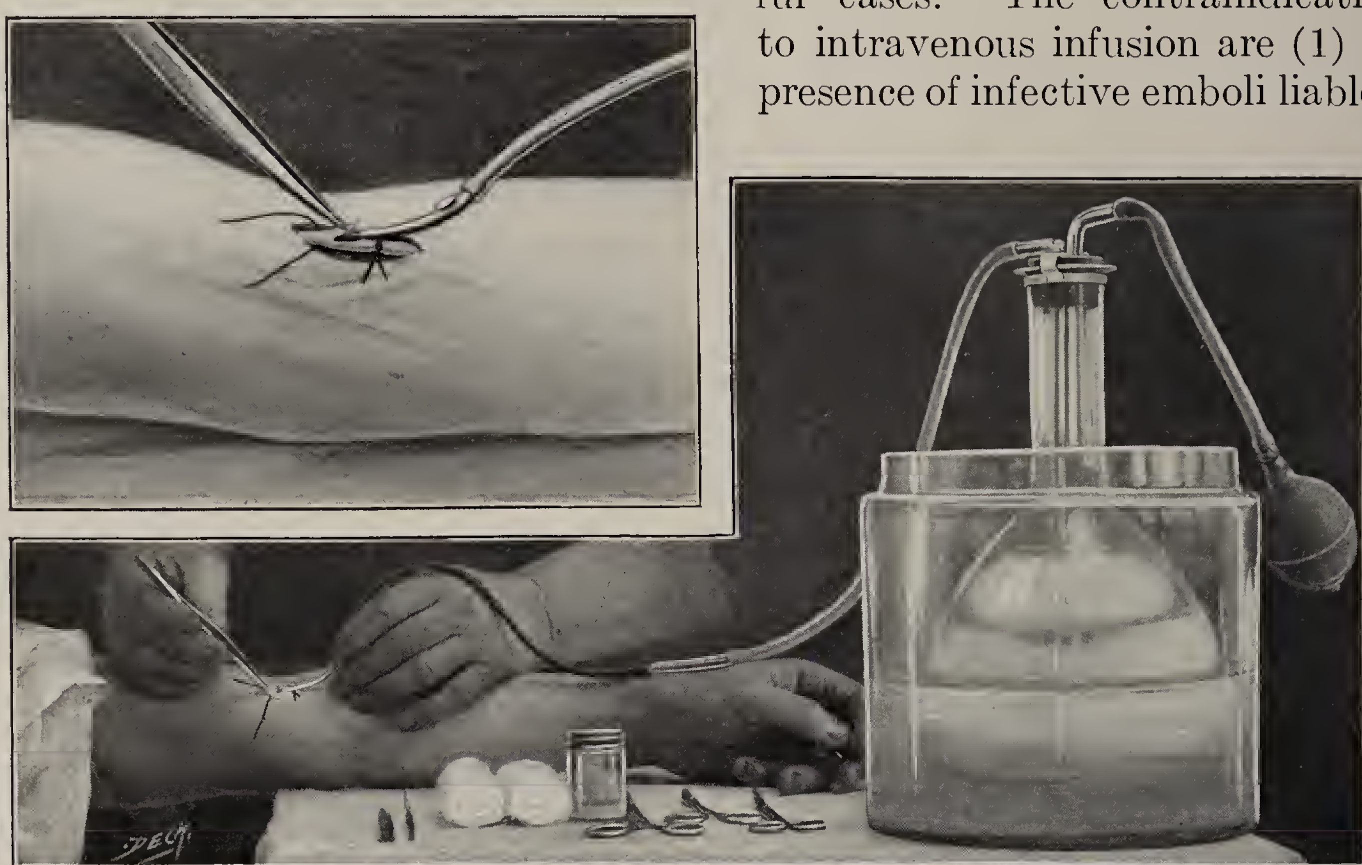
Venesection.—This little operation, formerly so frequently employed, is now but rarely called for. The median basilic vein at the bend of the elbow is usually chosen. The parts should be prepared in an aseptic manner, and a bandage applied sufficiently tight to restrict the return flow of blood, but it must not interfere with the circulation through the vessel, as shown by the pulse at the wrist. The superficial veins become filled. The escape of blood is favored by voluntary grasping movements of the hand. When sufficient blood has escaped, the constricting bandage is removed and an aseptic gauze bandage applied.

Transfusion.—Blood taken from the circulation of one individual and introduced into that of another in case of excessive hemorrhage has been practically abandoned in favor of intravenous normal saline infusion. This result has been brought about, first, because of the difficulty of obtaining blood in sufficient quantity; second, from the delay incident to the operation; third, on account of the risks from thrombosis and embolism when the direct method is employed, and the fever and hematuria when the indirect method is used.

Intravenous Saline Infusion.—This operation is usually performed either through the median basilic or the median cephalic, at the bend of the elbow. A constricting bandage is placed on the upper part of the arm to restrain the flow of blood from the limb. The vein is bared and cleared for about an inch, and two ligatures passed, one above the point of intended opening in the vein and one below (Fig. 135). A slightly curved cannula is now introduced through a small valve-shaped opening made in the vein by a snip with the pointed scissors, the infusion fluid being allowed to flow while this is being done, in order to guard against the entrance of air. The upper ligature is now tightened around the cannula to hold the latter in place, and to prevent leakage as well, while the lower ligature closes the vein below. The constricting bandage is now removed. If gravity is employed the reservoir containing the infusion fluid should be held about three feet above the patient's chest. Or the apparatus shown in figure 135 may be used. A 0.6 per cent solution of chlorid of sodium should be employed at a temperature of from 110° to 120° F. Szumann's transfusion solution consists of six parts of sodium chlorid, one part of carbonate of soda, and one thousand parts of sterile water. In case of emergency a transfusion fluid can be rapidly extemporized by dissolving a level

teaspoonful of table salt in a pint of boiled water. The solution should be strained or filtered. This solution, used at a temperature which the hand will bear without discomfort, will answer every practical purpose. The quantity will vary with the requirements of the case; from two and one-half to three pints is the usual quantity. Care is to be exercised not to inject too much in cases in which secondary hemorrhage is to be feared (Mikulicz).

Intravenous infusion is employed as follows: (1) for replacing lost fluids following severe hemorrhage; (2) for the restoration of heat to the body in surgical shock and analogous conditions; (3) for the removal of toxic substances by provoking diuresis in cases of renal insufficiency. It has also been used in illuminating-gas poisoning combined with venesection. Under these circumstances it is difficult to apportion the credit for the favorable outcome in successful cases. The contraindications to intravenous infusion are (1) the presence of infective emboli liable to be forced into the circulation by the operation; (2) the presence of advanced dropsy; (3) marked cardiac insufficiency; (4) cyanosis, or pulmonary edema.



A B

Fig. 135.—Intravenous Saline Infusion.

A, The lower ligature is tied and the upper ligature is in place ready for tying. The valve-shaped opening in the vein is shown ready to receive the cannula. B, Flask containing the saline solution. This flask is an ordinary wash-bottle, the long glass tube of which is connected to the infusion cannula and the short glass tube to a rubber bulb with valves. By pumping air into the flask above the solution the latter is forced into the veins.

The most frequent employment of intravenous infusion in surgical practice is in combating shock accompanying or following operations. It is in this class of cases that the higher temperatures are employed. The use of strychnin may be combined with that of the saline infusion when indicated. The strychnin is introduced along with the saline fluid by injection from a hypodermic syringe through the rubber tube of the apparatus. This should be done very slowly. Adrenalin chlorid in 1 : 1000 solution may be employed in the same manner. From 10 to 15 minims of the latter may be thus introduced and repeated every few minutes while the infusion is progressing, until its effects in increasing the blood-pressure are manifested (Crile).

Subcutaneous Infusion or Hypodermoclysis.—From one to two pints of the saline fluid may be introduced beneath the skin in cases in which

the indications for infusion are less urgent, or for the purpose of supplementing an intravenous infusion when this has been given. From one to three pints of the saline infusion may also be given by the rectum for the latter purpose. By these means the necessity for a second intravenous infusion may sometimes be avoided. For subcutaneous or intracellular infusion any large hollow needle will answer. This and a clean douche bag, an ordinary bulb syringe, or an irrigator to which the necessary rubber tubing can be attached constitute the requisite apparatus. The infusion is made beneath the breasts. Should it become necessary to repeat the infusion, the interscapular region or the inner surface of the thighs should be selected.

Autotransfusion consists in the temporary displacement of the blood in the direction of the essential vital organs in cases of excessive loss of blood in which death is threatened from embarrassment of the general circulation. One of the methods of effecting the displacement of the blood is to incline the patient at an angle of 45 degrees by raising the foot of the bed. By this means the force of gravity is made available and the action of the heart operates to force the blood in the direction of least resistance, namely, in the direction of the cardiac and respiratory centers. Another method is to hold the limb in a vertical position until it is practically deprived of its blood, when a constricting band is placed at its base to prevent the blood from reentering when the limb is lowered. A still more efficient method is to bandage the limb from below upward, its blood being rapidly forced out in this way. A limb may be kept deprived of blood in this manner for two hours with safety; in case of necessity, the limbs can be alternately bandaged or constricted.

Autotransfusion is of great value as a temporary resource. It should be employed only after the hemorrhage is arrested. It should not take the place of intravenous saline infusion, but may be used to gain time to make the latter available.

General Treatment of Hemorrhage.—Internal medication is of practically no value in the arrest of hemorrhage. Ergot, of so much value in postpartum hemorrhage from inertia of the uterus, is of no use in surgical hemorrhage except in cases of capillary oozing, and in these, except in the cases in which the bleeding area is not accessible, the method of tamponade may well replace it. It may be advantageously employed, however, in combating the shock resulting from hemorrhage, the caliber of the capillaries being diminished by its action as a vasomotor constrictor, and the heart better enabled to control the general circulation (Livingstone). Oil of turpentin is employed by some surgeons in five-drop doses, given in emulsion and repeated every half-hour. Its action is not assured and it is liable to produce strangury. Acetate of lead, the dilute or aromatic sulfuric acid, and similar drugs formerly believed to increase the coagulability of the blood, are no longer employed.

Stimulation is to be avoided as long as bleeding continues or is likely to recur. Once, however, the hemostasis is effective, stimulation is to be pushed by hot diluted alcoholic drinks, hot enemas of saline solution and whisky, and the hypodermic use of digitalis and strychnin for the purpose of bringing about reaction and combating excessive prostration. At the same time the heat of the body is to be restored by hot-water bottles applied to the extremities, and, if necessary, to the trunk as well. A hot-water bottle applied to the precordia sometimes answers a good purpose. In carrying out these measures care should be taken not to burn the patient.

OPERATIONS ON NERVES

Suture of Nerves.—This is required in complete accidental division of nerve-trunks. This injury occurs at points where nerve-trunks are superficially situated, such as the median nerve above the wrist or the ulnar nerve in elbow-joint resection. Contusion of a nerve may require removal of the contused portion and the suturing of the nerve-ends.

In the earlier attempts to suture nerves the method employed was that of transfixion of the entire nerve with interrupted sutures. The employment of a nonabsorbable suture led to frequent and mischievous suppurative inflammation. The use of catgut or other absorbable suture material, and improvement in the technic consisting of the suture of the neurilemma of the divided ends rather than the entire thickness of the nerve-trunk (Weber), together with Hueter's further modification of perineural suture (Fig. 136, suture of the connective tissue of each end), marked a very decided advance in the surgery of the nerves. Accurate approximation and healing without suppuration assure excellent results, in a large proportion of cases (about 67 per cent, P. Bruns, 1884).

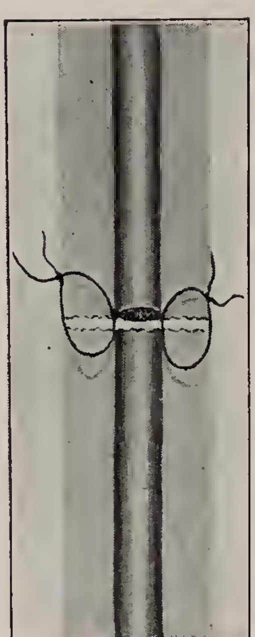


Fig. 136.—Perineural Suture.

Secondary Nerve-suture.—In cases in which nerve-trunks have been divided and the stumps buried in a mass of cicatricial tissue with loss of function, these may be dissected from their cicatricial surroundings and sutured. If the nerve-ends are readily approximated, Hueter's suture or Weber's neurilemma suture may be applied. If there is considerable tension on the nerve-trunk in replacing it, it will be necessary to apply the transfixion suture of the entire thickness of the nerve-trunk.

The results of secondary suture are very encouraging (24 successful cases out of 33, P. Bruns). One case was operated on nine years after the original injury, with a successful result. Though there are reports of extraordinarily rapid restoration of function, this varies, as a rule, from three months to two years.

Neuroplastic Operations.—In cases of marked retraction of the nerve stumps or loss of substance preventing ready approximation of the same, Létiévant (1872) proposed to turn down a flap attached by a pedicle from one nerve stump, and to attach this to the other. The most brilliant success in the employment of this procedure was achieved by Tillmanns, in a case of division of the ulnar and median nerves (1882). Another ingenious operation, also introduced by Létiévant, consists in suturing the central end of one nerve-trunk to the peripheral end of an adjacent nerve, when two neighboring nerves are injured.

In cicatricial union of nerves, without restoration of function, a longitudinal incision is made through the middle of the mass of scar tissue, extending well into the healthy nerve substance (Fig. 137, A). This is then converted into a transverse line and secured by suture (Fig. 137, B). In this manner, nerve-tissue is brought in contact with nerve-tissue (Bruns, 1893).

In cases of nonunion with **bulbous central end,** in order that a large amount of the length of the nerve may not be sacrificed in getting rid of the

latter, this is split well beyond the bulbous extremity, and the distal end trimmed to a wedge shape. The latter is then sutured into the split of the central end, as shown in Fig. 138 (B r u n s).

In order to prevent the sutured portion from being compressed by the **newly formed connective tissue,** it has been proposed to slip a decalcified bone tube over the nerve before suturing; or the tube may be split and passed around the nerve after suturing.

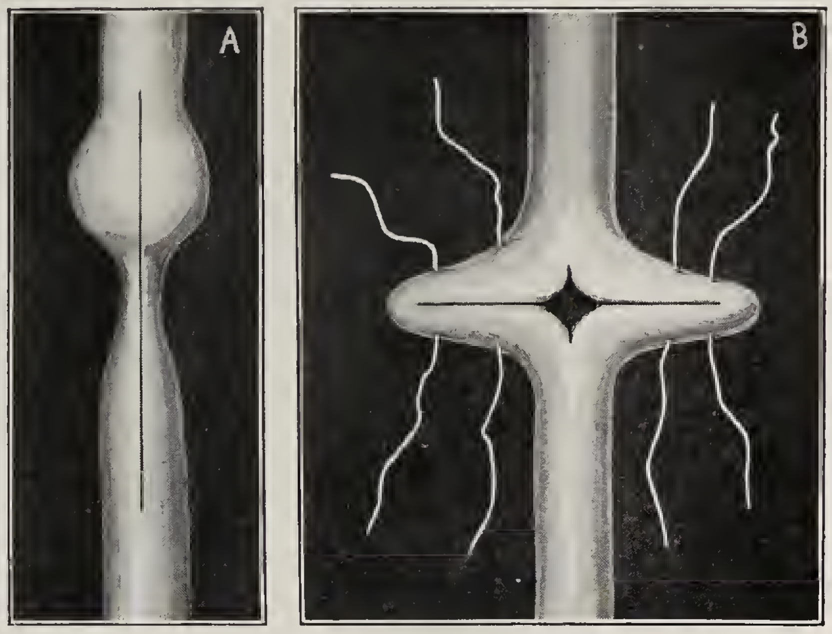


Fig. 137.—Bruns's Method of Nerve-suture.
A, Longitudinal incision through cicatrix extending into normal nerve; B, incision shown in A, united transversely.

Strangulation of a nerve from its embedment in a mass of cicatricial tissue or callus sometimes leads to impairment of function, without coincident injury to the nerve itself. The nerve should be liberated and enveloped in a T h i e r s c h skin-graft (G l e i s s) to prevent repetition of the accident.

After all operations of nerve-suturing the **position of the parts** should be carefully attended to. The limb should be placed so as to bring as little tension as possible on the sutured nerve. As soon as healing has taken place electricity and massage are useful adjuncts to treatment.

Transplantation of Nerves.—G l u c k in 1880, after P h i l i p a u x and V u l p i a n ' s experiments (1870) in transplantation of nerves in dogs, attempted to place the operation on a surgical basis and made some experiments for that purpose. This implantation of completely separated portions of nerves has never been successful in man, though it has been perfectly accomplished in some of the lower animals.

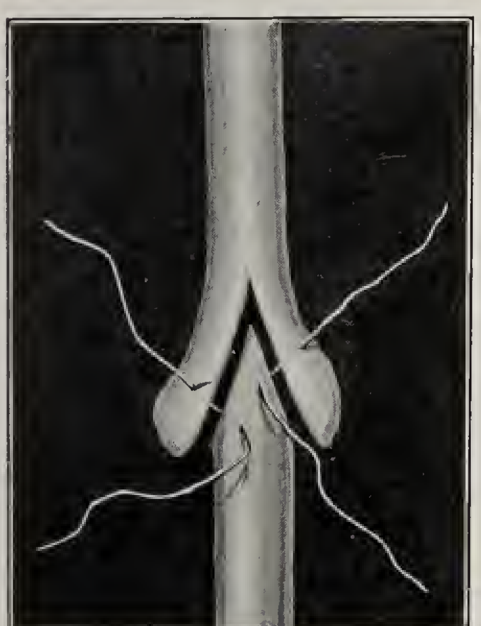


Fig. 138.—Nerve Stump United by Wedge Method.

Neurotomy and Neurectomy.—Intractable neuralgia sometimes assumes such importance as to demand division of the nerve for its relief. Otherwise inoperable but excessively painful tumors also require division of the sensory nerve supplying the organ involved, *e. g.*, division of the lingual nerve in inoperable carcinoma of the tongue. Formerly motor nerves were occasionally divided in cases of intractable painful convulsive movements in the region supplied, *e. g.*, division of the facial for tic douloureux. The operation of nerve-stretching has now quite superseded nerve-section in these cases.

Simple division, or neurotomy, is found to be quite insufficient to meet the requirements of permanent interruption of function in sensory nerves. For this reason the operation of neurectomy has taken the place of that of neurotomy. Without this, the violent pains which originally demanded the operation soon return. The object of neurectomy is to excise a portion of the nerve,

in order to prevent reunion of the divided ends. The removal of at least two inches has been shown by experiment to be necessary in order to insure against reunion. These operations are usually performed for intractable trigeminal neuralgia; it is manifestly impossible to remove two inches from any of the branches of the fifth pair. All that can be done, under these circumstances, is to remove all of the nerve accessible; this will usually include the trunk to the extent to which it passes through the bony canal, from its exit from the skull to its peripheral distribution. More recently the cavity of the skull has been invaded (see Intracranial Neurectomy, page 541).

Crushing of the Divided Central End of the Nerve.—This has been suggested to prevent a return of the neuralgia by arresting nerve regeneration. There is danger of inflammation progressing in the direction of the brain or spinal cord (**ascending neuritis**) occurring as a result of this procedure. Quite as effectual and far safer is the application of the thermocautery to the central end of the divided nerve.

Relapses of intractable neuralgia following neurectomy are not always due to reunion of the divided nerve-ends. The development of a neuroma on the central end, or the unfavorable influence of the cicatrix, in a certain proportion of cases, will account for the recurrence. Further, some of these cases have a central origin, the paroxysms depending on some peripheral irritation which is conducted along the intact nerve. The latter being divided, the paroxysms cease for a time only. The condition of these sufferers will sometimes demand repeated operation even though but temporary relief is obtained.

Extirpation of Tumors of Nerves.—Neuromas are found most frequently in amputation stumps, forming bulbous enlargement of the cut ends of the nerve-trunks. Since the introduction of aseptic wound treatment, however, they have been less frequently observed. They produce exquisite pain and prevent the wearing of an artificial limb. They are dissected out after the cicatrix has been split, the nerve-trunk on which they are situated being divided as far away from the stump as possible.

Neurofibromas may occur singly or in groups. When they occur singly, the tumor is usually situated on the lateral aspect of the nerve-trunk. The nerves of the skin of the lower extremities are more frequently attacked. These growths are exceedingly painful and require removal. This should be done without division of the nerve, particularly in the case of important nerves. Multiple neurofibromas, particularly the form known as plexiform neurofibromas, except when they occur on the extremities, or on the skin of the trunk, are not amenable to operative treatment.

Myomas of nerves are the most important nerve tumors that come under the notice of the surgeon. They are soft masses consisting of semifluid mucous tissue, the size of a child's head; when large, they are usually situated in the course of large nerve-trunks and have a feeling of pseudofluctuation. In some instances the large ones pass over the convex surface of the tumor, but few nerve-fibers invading the tumor; in other cases the latter seem to be a portion of the tumor itself. Paralysis of the nerve-trunk from which they spring is not common, the nerve-fibers seeming to preserve their conductivity in spite of their apparent involvement in the tumor. In the removal of these growths such nerve-fibers as are distinctly isolated may be preserved; otherwise the trunk must be divided at the limits of the tumor and the continuity of the former restored by a neuroplastic operation (see page 354).

Nerve-stretching has been successfully employed in cases of neuralgia in which bundles of nerve-fibers are bound down to the surrounding connective tissue by cicatricial attachments. The strong tension made on the nerve, under these circumstances, results in the stretching and the loosening of these adhesions. The method has also been employed in certain forms of neuritis; it has been followed frequently by temporary relief, and occasionally by cure. In convulsive tic douloureux stretching of the motor portion of the seventh nerve has also been successful. This is not a trustworthy method of treatment in intractable neuralgia, prompt relapse following any improvement obtained. It is now virtually abandoned in tetanus, tabes dorsalis, epilepsy, and degenerated processes in peripheral nerves.

Slight tension on a nerve increases the reflex excitability (Schleich), while decided stretching is followed by a temporary diminution of the excitability, or this may be abolished altogether (Valentine). The paralysis which follows nerve-stretching usually rapidly disappears. Nerve-stretching may be useful, therefore, when a nerve is in an excessively excitable condition, or when the symptoms are due to an inflammatory fixation or constriction of the nerve at some part of its course. It has been shown (P. Vogt) that the stretching of a nerve-trunk is followed by dilatation of the vessels of the nerve. This may give rise to beneficial nutritive changes.

In most instances the operation is applied to the large nerve-trunks supplying the upper and lower extremities. The nerve is exposed, isolated, and a band of gauze made by folding several thicknesses together which are passed beneath the trunk. This is formed into a loop by tying its ends together and is attached to a Chatillon spring balance scale. The tension is then applied and the amount of strain put on the nerve noted.

Breaking Strain of the Principal Nerves in the Body.—The breaking strain of the principal nerves in the body is as follows (Trombetta):

Great sciatic,	183	pounds
Internal popliteal,	114	"
Anterior crural,	83	"
Median,	83	"
Ulnar and radial,	59	"
Brachial plexus in the neck,	48 to 63	"
" " " axilla,	35 to 81	"

In applying the tension the strain must be divided, by proper division of the force, as nearly as possible between the central and the peripheral portion of the nerve.

So-called "dry stretching" of a nerve consists of making tension on the nerve by means of forcible changes in the position of the parts. It is used principally in connection with the sciatic nerve. (See Regional Surgery.)

OPERATIONS ON MUSCLES AND TENDONS

Suture of Muscles and Tendons.—Subcutaneous ruptures of muscles generally unite without operation. Open section of muscles, however, usually demands suturing. Silk is generally preferred for this purpose; the elasticity of the muscular tissue and its tendency to contract contraindicate the use of catgut. When employed for suturing muscles or tendons the silk should be as fine as possible, the suture should not be drawn very tight, and the knot ends should be cut as short as possible.

Traumatic Separation of Tendons.—This is of much greater frequency than the above, owing to the more exposed situation of the tendons. The divided ends recede at once to a considerable distance in the sheath. If permitted to remain, they become attached to surrounding structures and the function of the muscle is lost.

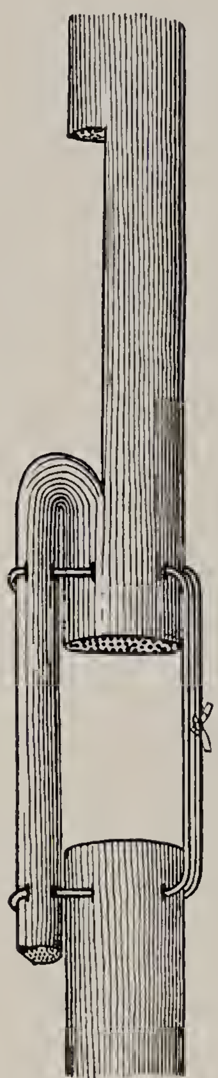


Fig. 139.—Method of Tendoplasty.

Suture of Tendons.—The tendon should be exposed by a curved incision so as to avoid a continuous cicatrix between the skin and the tendon. The sheath of the tendon is split in order to secure the retracted ends. These are then brought into position and secured by sutures of fine aseptic silk. In broad tendons several sutures should be applied. Whenever possible the ends should lap over each other, as the peritendinous connective tissue is much more vascular than the tendon itself. The slight shortening which results does not interfere with the future usefulness of the tendon. The wound is closed and a fixed dressing applied to support the parts in a relaxed position.

Tendoplasty.—This procedure is employed when, either from destruction of a portion of a tendon, or in cases of old injury, there is an inability to approximate the retracted ends. A flap is formed from one end of the divided tendon, turned down and sutured to the other stump (Fig. 139). If necessary, in order to fill a greater defect, a similar flap may be taken from the other extremity also (Fig. 140).

Threads of catgut and aseptic silk have been made to stretch across from one stump to the other in cases in which it was impossible to bring these together. The implanted material is healed in, and, in case the wound pursues an aseptic course, becomes gradually absorbed and is replaced by connective tissue. A piece of tendon transplanted from a lower animal will, if the operation is successful, behave in the same manner.

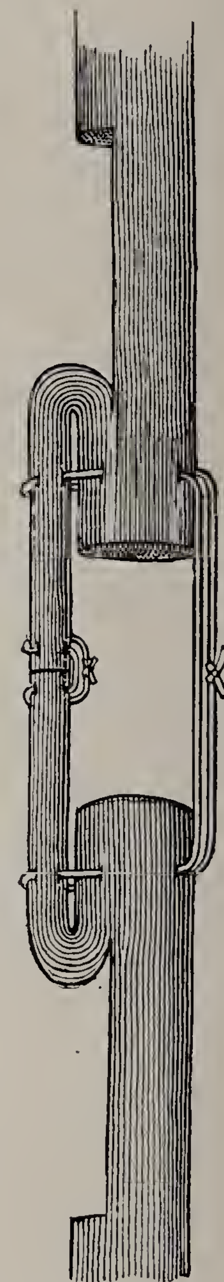


Fig. 140.—Double Tendoplasty. Flap taken from each stump of tendon (Trnka).

Lengthening Contractured Tendons.—A longitudinal incision is made in the middle line of the tendon, from each end of which a cross-cut is carried to the edge of the tendon in opposite directions. The tendon is then separated, lengthened, and sutured as shown in Fig. 141. Another method consists in making two parallel incisions in the tendon, each two inches long, one being three-eighths of an inch higher up on the tendon than the other. The opposite ends of these incisions are carried to the edge of the tendon (Fig. 142). By traction the central portion is straightened out and the tendon is lengthened by an amount equal to the length of the incisions.

Vicarious Tendoplasty.—Failure to identify the retracted central end of a tendon constitutes one of the indications for this procedure. The peripheral

end is identified and freshened. The tendon of an adjoining muscle is now split, one half of its tissue utilized for attachment to the injured tendon, the other half retaining its normal connection. In injury of the tendon of the extensor longus pollicis or that of the extensor brevis pollicis, the tendon of the extensor carpi radialis longior may be split longitudinally, a flap turned down and sutured to the peripheral stump of the injured tendon (S c h w a r t z). In cases of old injury of the muscles and tendons of the forearm in which the retracted ends cannot be brought together the extensor communis digitorum may be split and a flap of the muscle itself turned down and attached to the peripheral tendinous stump (S c r i b a). This method may also be employed in certain cases of talipes. The divided peroneal tendons may be united to the tendo Achillis to assist the action of the latter in paralytic calcaneus. In paralytic valgus the extensor proprius hallucis is frequently unaffected and may be employed to substitute its action for that of the paralyzed tibialis muscle by cutting away the sheaths of both tendons which run side by side, scarifying and suturing them for an inch or more, the foot being strongly inverted so as to shorten up the tendon of the tibialis anticus and pull down the tendon of the extensor hallucis (P a r r i s h , 1892). Or, the tendon of the extensor proprius hallucis and the anterior tibial tendon may be divided, the proximal end of the former being sutured to the distal end of the latter; the distal end of the extensor pollicis is united to the common extensor of the toes.

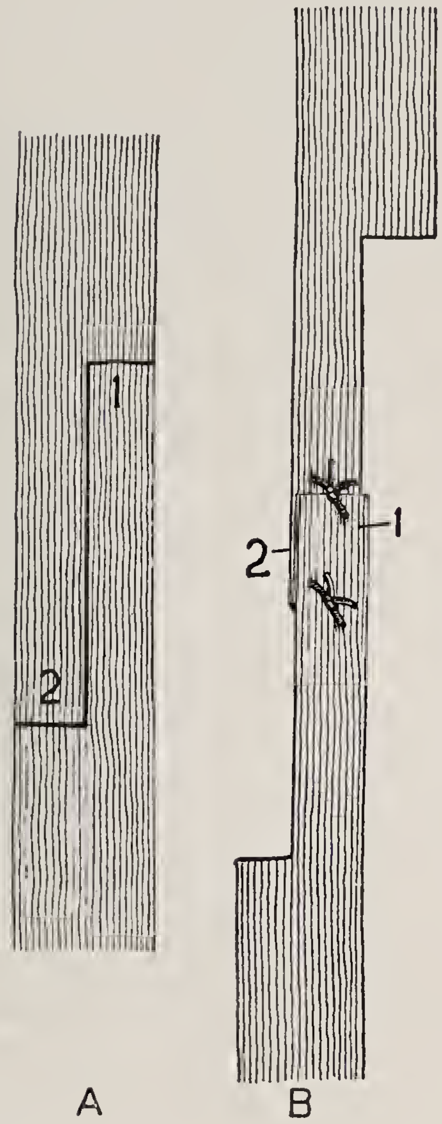


Fig. 141.—Lengthening a Tendon.

A, Method of dividing the tendon; B, method of reuniting the tendon.

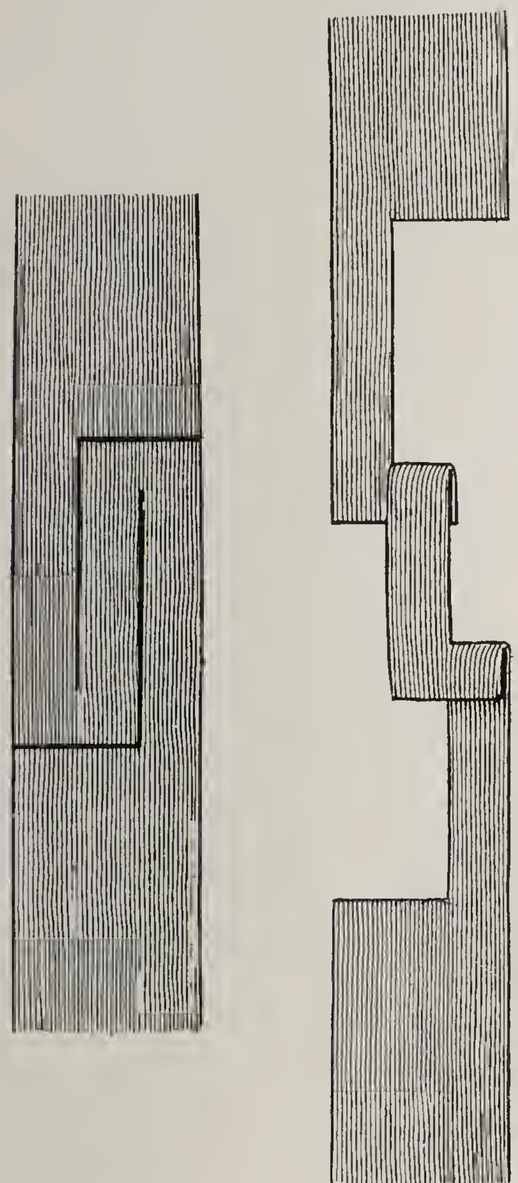


Fig. 142.—Tendoplasty.

Suppurative Inflammation in Sheaths of Tendons.—Rapid infection may take place by this means. The sheath must be opened up freely by means of the probe bistoury and thoroughly irrigated by means of an antiseptic solution; otherwise the necrotic changes will destroy the tendon itself, or its function will be impaired by the formation of adhesions between the tendon and the sheath. If, in order to reach a deep abscess, it becomes

necessary to pass through a mass of muscular tissue, this may be advantageously accomplished by first passing through it a blunt probe or director and then the closed blades of a dressing forceps, which should be open when withdrawn. The hemorrhage which follows incision of the muscle is thereby avoided. In following up burrowing pus the uterine repositor (Fig. 165), used as a director or probe, is introduced in case the finger fails to reach the extreme limits of the pus cavity, and the screw on the handle turned until the extremity of the instrument marks externally the point where the counter-opening is to be made. The skin and fascia are now incised, and the director and dressing forceps relied on for the rest.

Myotomy and Tenotomy.—The essential indication for these operations is the existence of contracture of muscular or tendinous origin, such, for instance, as section of the sternomastoid for wry-neck (page 651), the tendo Achillis in paralytic talipes equinus (see Regional Surgery), as well as various contractures of cicatricial and arthritic origin. Prior to the introduction of anesthesia, tenotomy, which is always the preferable procedure when practicable, was somewhat indiscriminately performed; at the present time its employment is more restricted. In contractures of the knee-joint, and particularly in the early treatment of clubfoot, forcible restitution under anesthesia and retention by proper means (see Regional Surgery) have to a great extent replaced tenotomy.

The methods of lengthening contracted tendons already described have still further narrowed the field of simple transverse tenotomy.

Subcutaneous Tenotomy.—To Stromeyer and Dieffenbach we are indebted particularly for the development of this method of tenotomy (1840-1850). By means of this procedure much less risk of suppuration in the wounds was incurred. At the present day, however, the employment of aseptic precautions renders open tenotomy an almost dangerless procedure and permits its employment in situations in which injury to important structures may follow the subcutaneous method, *e. g.*, to the subclavian vein in section of the sternal attachment of the sternomastoid, and to the external popliteal nerve in division of the tendon of the biceps flexor cruris.

An anesthetic should always be employed in myotomy and tenotomy. Otherwise involuntary contraction of the muscles may embarrass the operator. The muscle should be put on the stretch as much as possible. The tenotome (Fig. 143) is introduced flatwise, passed immediately behind the tendon, and the latter is divided from behind forward by short sawing movements of the instrument, the operator's left thumb pressing on the tendon from without. The operator is thus enabled to determine when the edge of the blade approaches the skin, and to avoid cutting the latter. The tendon will be felt to give way, if forcible restitution of the parts is made at the same time; sometimes this occurs with a snap or jerk, due to rupture of the last few fibers. The tenotome is then withdrawn and the wound closed by the thumb until a compress of antiseptic gauze is applied and secured in place by a roller bandage.

Operations for the Removal of Tumors of Tendons.—No definite rules can be laid down for the removal of these tumors. **Fibromas** may usually be enucleated by splitting the muscle in the direction of its fibers. In **sarcomas** the most careful dissection will not give immunity against recurrence.

Ganglions spring from the sheaths of tendons and may be treated success-

fully during the first few weeks of their existence by means of massage or methodically applied pressure. The old method of rupturing the sac by a sharp blow with the back of a book not infrequently fails and is a barbarous procedure. **Subcutaneous incision** and the pressing of the contents into the surrounding connective tissue, from which they are absorbed, is preferable. The wall of the sac may be scarified from within at the same time. Pressure by means of a compress and bandage is then applied. Aseptic incision, followed by extirpation of the sac wall, if carefully performed, is the ideal

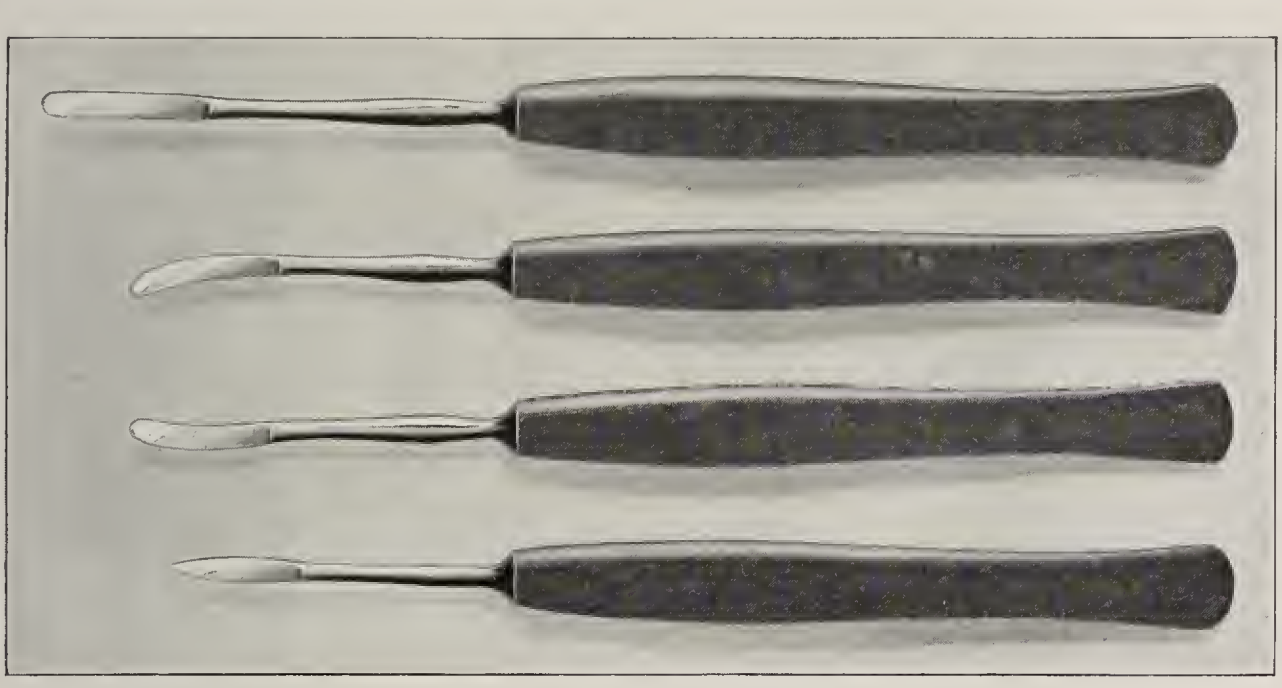


Fig. 143.—Tenotomes.

method of dealing with these tumors. Even if small portions of the sac wall are left behind, recurrences are rare.

Movable bodies occurring in tendinous sheaths, as well as in bursae, may be removed by incision. In the case of the latter, extirpation of the entire sac wall may be indicated on account of the usual coexistence of hyperplastic synovitis, in connection with which some semisessile rice bodies are usually found to exist. This, however, is not practicable in the case of tendinous sheaths.

OPERATIONS ON BONES

The Division of Bones.—Bones are divided either by fracture, osteoclasis, sawing, chiseling, or cutting.

Fracture may be accomplished by the hands, when the solidity of the structure is not too great to permit the employment of this method, or the conformation of the parts such as to render it impracticable (*e. g.*, insufficient leverage, or the interposition of thick muscular structure preventing a firm grasp). Under the latter circumstances osteoclasis or instrumental fracture is indicated. The most perfect instrument for the purpose is shown in Fig. 144.

Division of Bone by Sawing.—Saws of different patterns have been devised. The most practicable of these are the broad saw (Fig. 82), the frame saw (Fig. 83), the keyhole or metacarpal saw (Fig. 148), the chain saw (Fig. 145), the wire saw of Gigli (Fig. 147), and the trephine (Fig. 84). For ordinary amputations either of the two first named answers. In resections in which it may be desirable to change the direction of the blade in order to give a certain conformation to the sawed surface, the frame saw with a mechanism

for accomplishing this is useful. The metacarpal saw (Fig. 148), or keyhole saw as it is sometimes called, is useful when it is desirable to introduce the

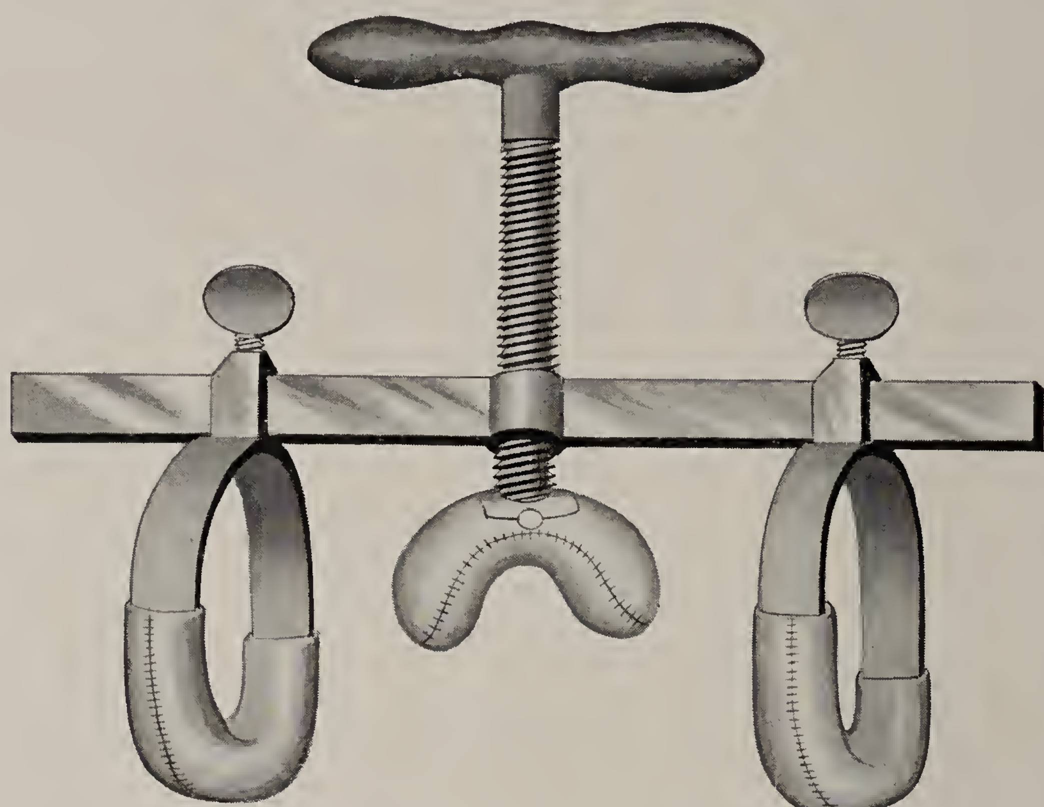


Fig. 144.—Rizzoli's Osteoclast.

instrument through a small opening or to saw on a curved line. A modification of this instrument for purposes of subcutaneous osteotomy is that known as Adams's saw (Fig. 149).

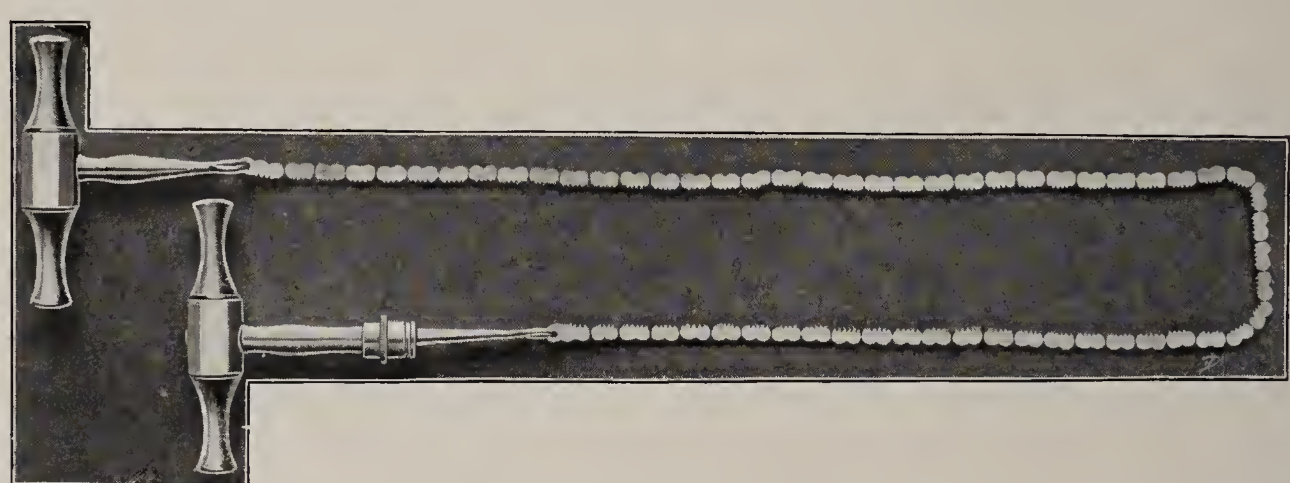


Fig. 145.—Chain Saw.

The chain saw is led around the bone by means of the chain saw carrier (Fig. 146) or a large curved needle. A loop of silk is first drawn around and

Fig. 146.—Chain Saw Carrier.

to this the saw is attached. The wire saw of Gigli has largely replaced the chain saw. Pinching in the furrow and consequent breakage of the chain or

the wire saw may be best avoided by holding the handles of the instrument wide apart in the manipulation, the saw thus describing a very obtuse angle.

In the manipulation of the broad and the frame saw the heel of the instrument should be first applied to the bone and the act of sawing commenced by a slow and steady drawing movement and strong pressure. For the rest of the

Fig. 147.—The Gigli Wire Saw.

manipulation the usual to-and-fro movements are executed. The assistant who steadies the parts to be removed should do this in a manner which will tend slightly to separate the sawed surfaces, in order to prevent the saw from becoming pinched. Too great force applied in this direction, however, should be avoided, else the bone will be prematurely broken before it is sawed completely across.

Fig. 148.—Metacarpal Saw.

In former times great stress was laid on the occurrence of necrosis as the result of sawing the bones. The influence of sepsis and consequent inflammatory conditions were not properly appreciated. It is now known that the nutrition of bone is not easily destroyed by this means, if septic complications are avoided.

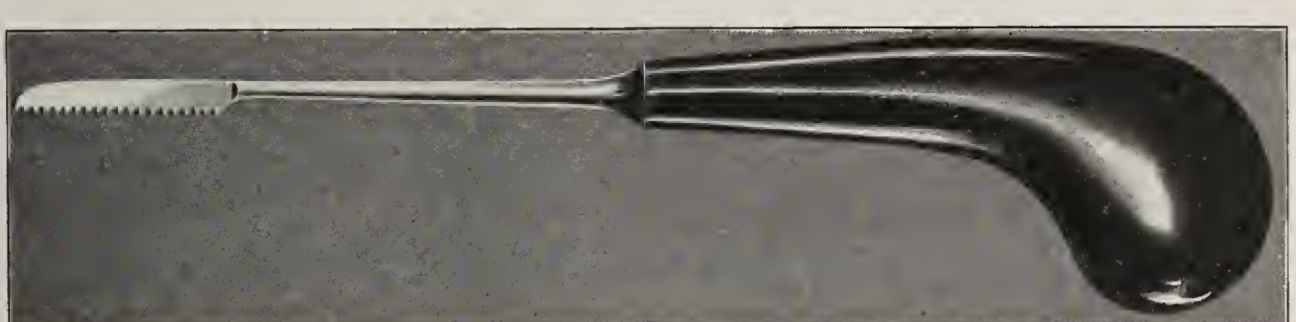


Fig. 149.—Adams's Saw.

Division of Bones by Chiseling.—Chisels are made either tapering or wedge-shaped (Macewen, Fig. 89), with beveled edges, or hollowed out on one surface (gouges). The latter may sometimes be used as hand gouges. The usual method of using the chisel, however, is in connection with the mallet (Fig. 150), which is preferably made of lignum-vitae or other hard wood.

Where a simple straight cut is to be made, particularly in the cancellous structure of bone, as in supramalleolar osteotomy (Macewen), the wedge-shaped or tapering chisel is to be preferred. To prevent "binding," as the instrument advances into the depths of the bone, a more bluntly shaped instrument is at first employed; this is subsequently followed by one less blunt, and finally by a comparatively slender instrument.

In cutting away portions of bone the beveled chisel is to be used. It is held at a very obtuse angle to the bone, in order to cut away wedge-shaped pieces. The V-shaped groove which is thus produced may be "squared" at each margin of the cut before completing the section. The chisel must not be held

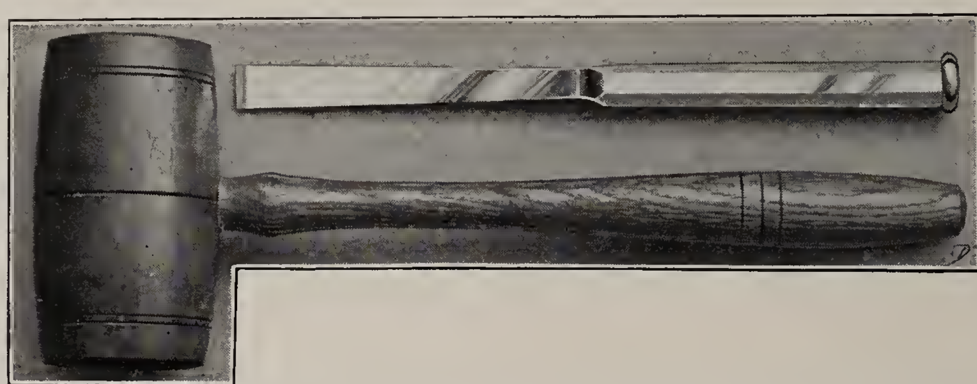


Fig. 150.—Bone Chisel and Mallet.

too firmly, else a portion of the force of the blow will be lost. Neither must it be held too loosely, or it may deviate from the course intended. When thin slices are to be removed parallel to the surface, the bevel side of the instrument is to be placed next to the bone.

With the acquirement of skill in the manipulation of the chisel and mallet the surgeon will be enabled to substitute these for the trephine almost entirely (see page 444).

Division of Bone by Cutting Forceps.—Though bone in its very young state and in certain pathologic conditions may be divided by means of the knife or scissors, bone-cutting forceps are usually employed for this purpose. These are made in several patterns, those of Liston and Luer (see page 317)

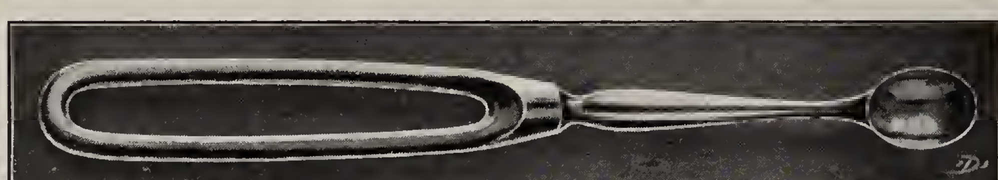


Fig. 151.—The Sharp Spoon.

being the best known. The first named have plain cutting-edges which meet instead of passing each other, as in the case of scissors. Luer's forceps are also known as the rongeur. A well-made Liston forceps may be advantageously substituted for the metacarpal saw in dividing such small bones as those of the metatarsal and metacarpal regions, as well as in making the section of the ribs in Estländer's operation of thoracoplasty. The rongeur forceps (Fig. 90, A) may be used as an adjunct to other bone-cutting instruments, as, for instance, in cutting away the small toothlike projections left on sawed or chiseled bones.

The **sharp spoon** (Fig. 151) is also employed in cutting bone, somewhat in the same manner as the hand gouge. It is much more effective than the latter,

however. It has been improved so as to permit of simultaneous cutting and irrigating (Fig. 94).

Coaptation of Bone by Operative Means.—Laterally placed openings, as, for instance, those produced in the operation of sequestrotomy (page 369), will not permit approximation of the edges of the opening. In certain joint resections, in which transverse sections of the bone have been made, it may be undesirable to promote union of the sawed surfaces directly (subperiosteal resection). The simple application of a retention bandage, and perhaps the application of extension, is here indicated. In cases in which union is desired and the fixed dressings are not sufficient to insure coaptation of the fragments, operative fixation is indicated. In accomplishing this the method of mortise coaptation is sometimes employed (Fig. 152).

Bone Suture.—This, when properly applied, will accomplish all that can be accomplished in operative fixation of the fragments. It should replace the methods of clamping, the use of metal plates, rods, and steel screws, and pegs of metal and ivory, etc. The following points should be borne in mind: (1) The entire limb, except the site of the operation, must be carefully bandaged with a sterile bandage in order to maintain asepsis during the operation; (2) the incision should be no larger than necessary and the parts must be carefully manipulated in order to prevent further devitalization. Forcible protrusion of the bone from the depths is to be discouraged; the operator should work by the sense of feeling as much as possible.

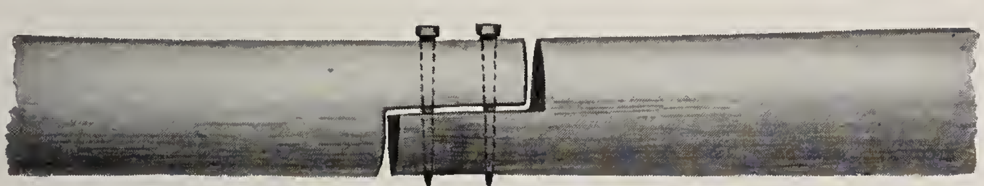


Fig. 152.—Mortise Coaptation of Bone with Ivory Pegs.

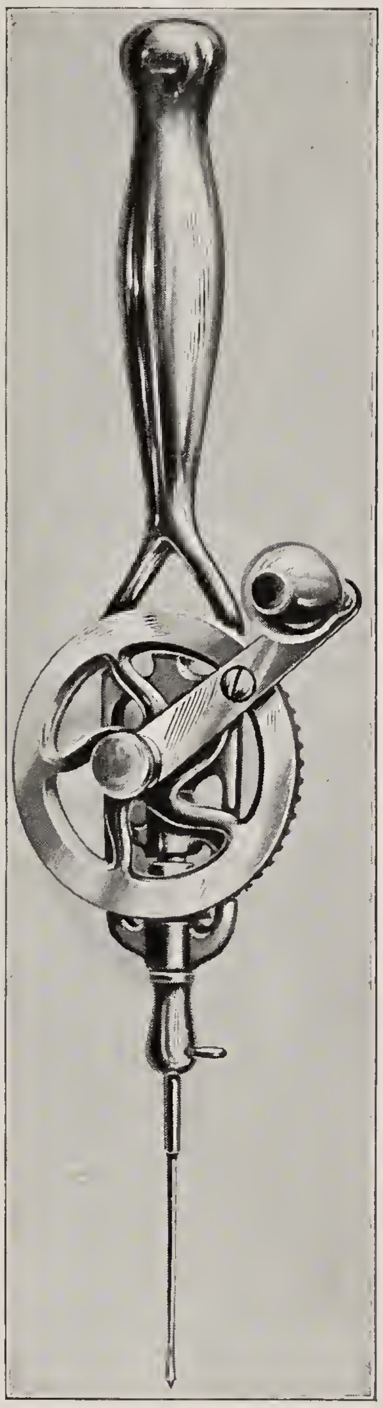


Fig. 153.—Bevel-gear Bone Drill.

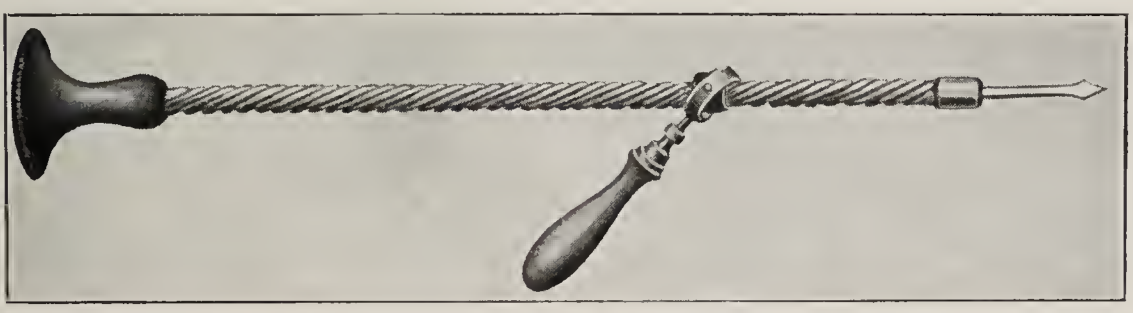


Fig. 154.—Jeweler's Drill.

The instruments required are (1) a proper drill (Figs. 153 and 154); (2) a hook for drawing the suture through the holes; (3) several stout strands of silkworm-gut to serve as "leaders," or light copper wire for the same purpose;

(4) forceps to twist the wire and a wire cutter. A narrow and pointed metacarpal saw may be needed.

In the application of the wire the following points in the technic must be observed in order to obtain the best results:

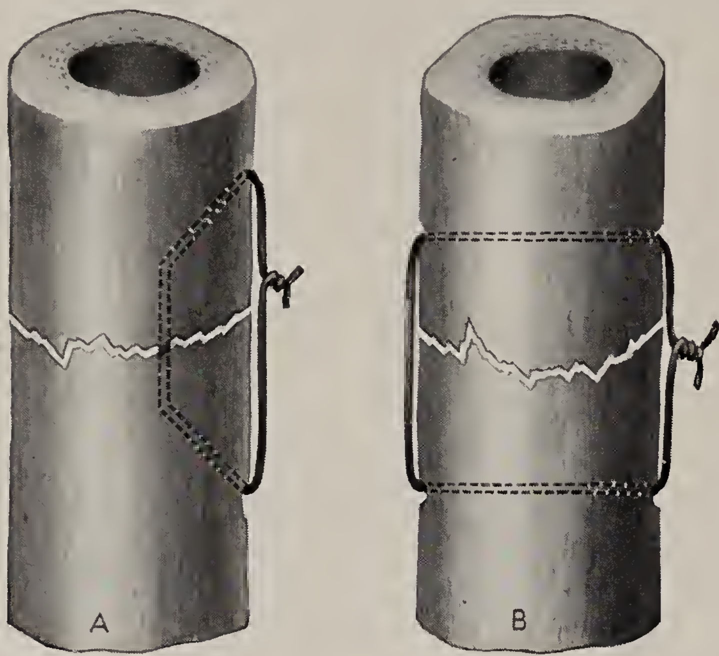


Fig. 155.—A, Faulty Method of Applying the Bone Suture; B, Correct Method (after Wille).

1. The shorter the distance between the drill holes consistent with securing a firm hold on the fragments, the less will be the chances of subsequent displacement.

2. The line of traction or the binding force of the suture must be placed as nearly as possible at right angles to the line of fracture. This is easily accomplished when the drill holes are properly placed (Fig. 155, B). In oblique fractures this will naturally remove the drill holes from the middle line of the bone (Fig. 156, A); otherwise the very undesirable effect shown in Fig. 157 will be produced. In very oblique fractures there may not be room enough for the drill holes, in which case a wire sling may be placed tightly around both fragments so as to bring the binding force in the proper direction; grooves are made in the bone with the metacarpal saw in which to engage the wire (Fig. 156, B).

Another method of securing a very oblique fracture is shown in Fig. 158, A. The fragments are brought into alignment and both drilled vertically in the center of the fracture surfaces. The silver wire is now passed to its middle behind the bone, and its "bite" caught by a hook or leader passed through the holes. The wire, doubled upon itself, is drawn through on the withdrawal of the hook. By dividing the loop thus formed, after it is drawn through, two separate and permanent binding sutures are formed (Fig. 158, B) (Wille; Hennequin).

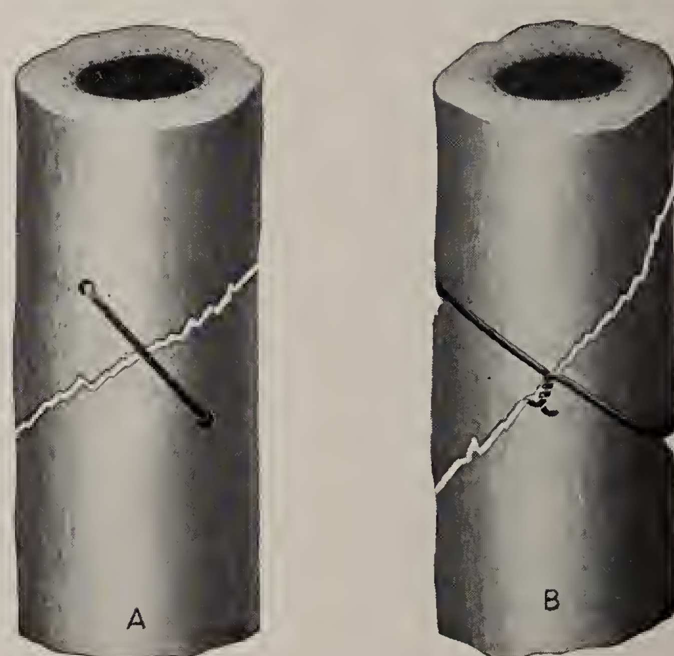


Fig. 156.—A, Proper Method of Applying the Bone Suture in Oblique Fracture; the Drill Holes are Placed in such a Manner that the Wire Suture is at Right Angles to the Line of Fracture; B, Sling Suture Applied to an Oblique Fracture (after Wille).

Operations on Bones after Fractures.—Some of the procedures discussed in the foregoing may be necessary after fracture. In addition, some special operations are required, particularly in fractures complicated by an externally communicating wound (compound fracture, accompanied or otherwise by extensive comminution).

In extensive extravasations, even in subcutaneous fracture, it will occasionally be necessary to make an incision and turn out the clot. This should

be resorted to only in extreme cases, such as urgent hemarthrosis of the knee-joint complicating fractures of the patella. Ordinarily in blood extravasations about fractured bones, unless the supervention of high fever and increasing sensibility of the part leading to a suspicion of sepsis demand interference, it is better to wait patiently for nature's efforts at resorption. If incision is made, the most rigid aseptic precautions and antiseptic treatment are necessary.

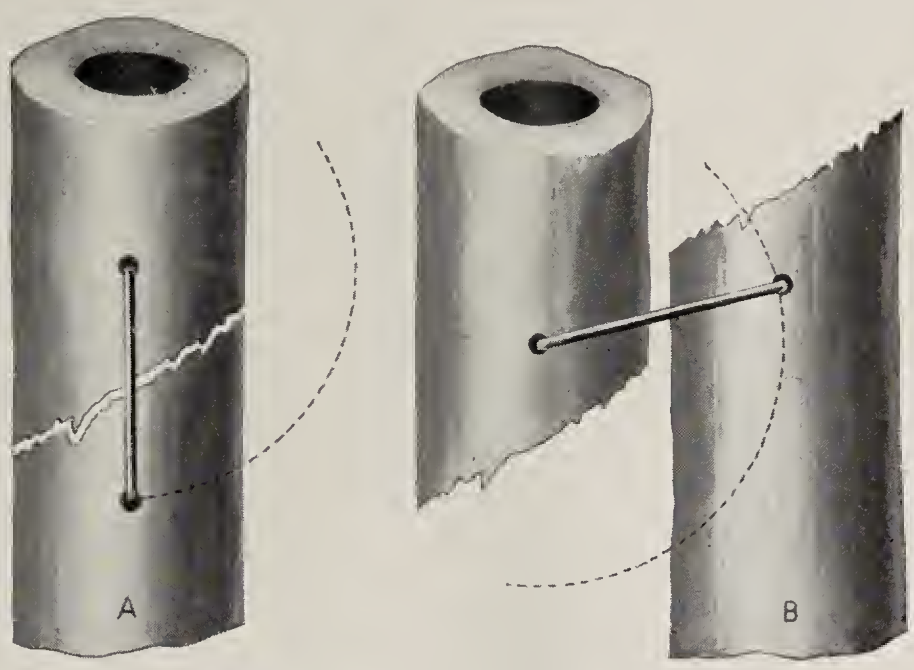


Fig. 157.—A, Faulty Method of Applying the Bone Suture in Oblique Fracture; B, Mechanism of Possible Displacement of the Fragments in Faulty Method of Bone Suture in Oblique Fracture (after Wille).

In compound fractures, in addition to the indications offered by the requirements of aseptic and antiseptic measures, drainage, and the removal of foreign bodies, it may become necessary to remove isolated portions of bone. Under these circumstances every effort must be made to preserve as much of the periosteum as possible. In separating the fragments from the periosteum the elevator (Fig. 159) will be found useful. In oblique fractures, not comminuted, one of the fragments may project from the wound and require removal in order to effect reduction. So-called **diaphysial resection** should not be resorted to, on account of the large defect remaining, except under the most urgent circumstances. In case of fracture extending into a joint the projection of a portion of the latter through a wound of the soft parts may require resection.

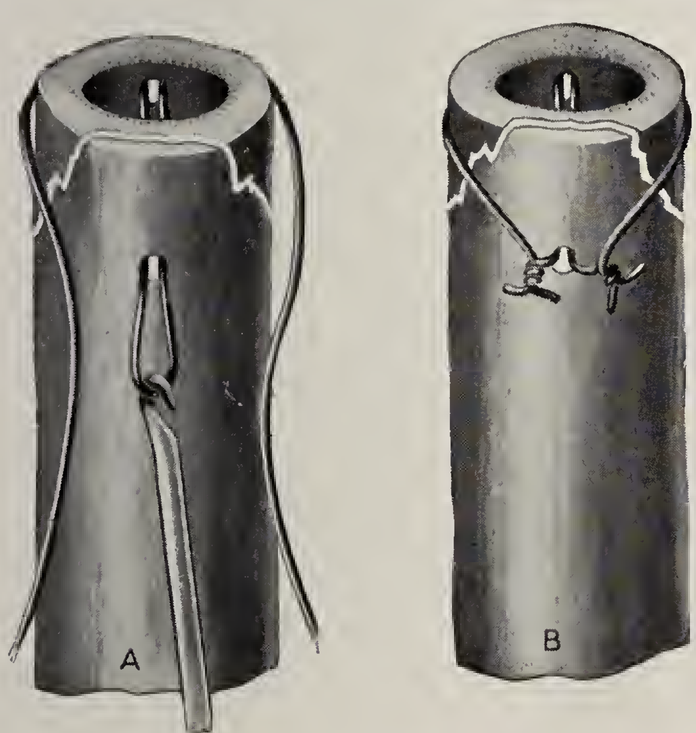


Fig. 158.—A, Method of Securing the Fragments of an Oblique Fracture in Position by Means of a Loop Suture Passed through Both Fragments; B, the Loop Suture Divided and the Two Halves of the Loop Twisted Together (after Wille).

Operations for Ununited Fractures.—The conditions existing under these circumstances vary considerably and methods of treatment must be adopted in accordance with the requirements of individual cases.

Delayed Union.—Percussion of the soft parts over the seat of fracture (Thomas) by means of the handle of a percussion hammer, a rubber faced mallet, or other instrument, the parts being protected from direct injury by a folded compress, will fulfil the indications in a certain proportion of cases. A daily séance, or thrice weekly séances of from five to ten minutes, until decided reaction is established, should be prescribed; if necessary, ether may be

administered. The limb is kept in a fixed bandage in the intervals. When considerable tenderness and some swelling have supervened, a plaster-of-Paris bandage should be applied so as to maintain exact immobilization for three or four weeks. This failing, **rubbing the fragments together under an anesthetic** may be tried. **Needling** after the method of Starke (the introduction of a stout needle or an awl, and its manipulation about the ends of the fragments in order to produce effusion) may accomplish the object.

All of these methods failing, a condition of **pseudarthrosis** exists, for which the following methods of treatment have been resorted to, in addition to those above described:

1. **Implantation of Ivory Pegs.**—In this operation two small incisions are made, one above and the other below the seat of fracture, and a conical ivory peg driven into each of the fragments a short distance from the seat of fracture. Reposition and retention follow. If the procedure is accomplished without aseptic precautions, union may be secured, but at great risk from septic conditions. If strict aseptic precautions are observed in the treatment, the chances of success are remote, owing to the very slight reaction which follows.

2. **Resection of the Fractured Surfaces.**—This method, combined with bone suture following the resection, is comparatively devoid of danger under aseptic conditions and offers the advantage of inspection and recognition of the conditions present, such as the interposition of soft parts, as well as the opportunity for the removal of these. The ends of the fragments are exposed,

FIG. 159.—PERIOSTEAL ELEVATOR.

a cuff of periosteum turned back from each, the surfaces of the former sawed off so that they will make proper support for each other, and the cuffs of periosteum sewed together with catgut. A fixed dressing is applied, the external wound, if asepsis has been preserved, being closed. Bone suture may be added to the periosteal suture. Whatever method may be indicated in individual cases, the periosteum must be preserved. The slight production of callus from the medullary tissue is insignificant, compared with that furnished by the periosteum.

Bone Transplantation.—In cases in which pseudarthrosis is due to a long defect from considerable loss of osseous substance, after necrosis for instance, bone transplantation (Nussbaum) is indicated. By means of the chisel a piece of bone, still attached to its periosteum, is loosened and brought around so as to bridge over the gap. The pedicle of periosteum is twisted upon itself. Or, a bone flap may be obtained by splitting an adjoining bone and bringing this, still attached by its periosteum (the muscular and fascial attachments of the latter being preserved as well), into position so as to fill the gap. The bone flap thus transplanted must accurately fill the defect. The method is not applicable to pseudarthrosis without bony defect.

Operations in Inflammation of Bone.—Immediately on the recurrence of suppuration, incision and drainage are indicated. In case of suppurative foci in the medullary canal, the bone is to be chiseled away in order

to establish drainage, or the softened cortical lamella may be perforated with the points of a closed anatomic forceps. The sharp spoon is applied, all granulating material scraped away, and gauze drainage employed. In **acute suppurative myelitis** incision and drainage will frequently give better results, if applied sufficiently early, than extensive resection or removal of the entire bone. When delayed, however, sequestra and an involucrum form and require the operation of **sequestrotomy. Myelitis granulosa** differs from acute suppurative myelitis by producing suppuration more slowly. The slow formation of the resulting abscess usually delays operative interference. When these abscesses are situated centrally, their situation is first determined by exploratory drilling; the opening thus made is subsequently to be enlarged by means of the chisel and mallet.

Sequestrotomy.—Sequestra involving the cortex only may be removed as soon as formed; those involving the entire thickness of the bone should be permitted to remain until an encasement of new bone has formed about the diseased portion, unless profuse suppuration which threatens life compels interference.

Esmarch's bandages should be applied. The fistulous opening leading down to the diseased bone is enlarged by means of the probe-pointed bistoury. The site of the cloaca is now investigated. This is enlarged by pushing back the periosteum and chiseling away its edges with the gouge and mallet. Two

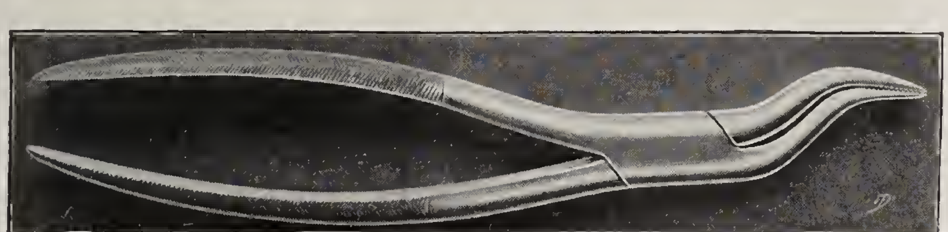


Fig. 160.—Sequestrum Forceps.

cloacae situated near each other may be connected. If the examination discloses an entirely movable sequestrum, this may be removed at once by means of the sequestrum forceps (Fig. 160) or the elevator (Fig. 159). Or the sequestrum may be removed after being divided. This failing, a large portion should be chiseled away to permit the passage of the detached portions. The ingenuity of the surgeon will be able to overcome the mechanic difficulties; as little as possible of the involucrum of new bone should be sacrificed, though equal care is to be exercised in the removal of all diseased bone. A repetition of the operation is frequently necessary.

The incised soft parts are sutured and the cavities drained after thorough antiseptic irrigation. Insufflation of iodoform powder or of salicylic acid is sometimes practised with benefit.

Excavation of Bone; Evidement.—This operation is employed in the treatment of **caries** resulting from **myelitis granulosa.** The focus of inflammation and suppuration is to be sought for through the fistulous canals, if such exist, and made accessible for purposes of thorough removal by means of the sharp spoon of all products of disease from the medullary canal, as well as the broken-down osseous structures. Small foci are sometimes scattered through the otherwise healthy appearing marrow; only complete removal of this will insure a complete cure. In some instances nothing but the sheet of cortical substance and the articular extremities of the bone are left. It is sometimes supple-

mented by the application of the actual cautery to the site of the primary focus. If the cortical lamellae are affected, evidement may not suffice, and *partial* or *total* **resection,** or, in the case of short bones, *e. g.*, the metatarsal and metacarpal bones, **extirpation** may be necessary. If a joint is found to be invaded, this, too, must be attacked. After resection the sawed surface is to be carefully examined and all suspicious looking points scraped out with the sharp spoon. Evidement and sequestrotomy are frequently combined, as in tuberculous ostitis, though amputation must frequently replace both these and resection, as, for instance, when several bones and joints of the tarsus are simultaneously involved, when general miliary tuberculosis or amyloid degeneration of internal organs is threatened. In elderly persons, in whom the periosteum rarely regenerates bone, amputation is to be preferred, as a rule, to the more conservative procedures.

Operations for Tumors of Bone.—The variety of osteoma which is attached to otherwise healthy bone by a narrow base or pedicle (**exostosis**) is removed by being completely exposed and either sawed off or chiseled away. In exostoses having a broad base, the mallet and chisel are employed. It is sometimes necessary to make a transverse section of the bone itself, in order to remove the growth completely.

Chondromas.—These may spring from the cortical lamella or from the medullary cavity. They are usually adherent by a broad base. The former, as a rule, may be removed by the knife. The latter are either lifted out of the medullary substance, or resected, as in osteoma. Complete removal is not always necessary. A removal of a portion of the tumor sometimes results in ossification of the remainder, particularly when the tumor springs from the medullary cavity. In the case of an important bone partial removal should be tried before resection or amputation is resorted to.

Malignant disease of bone is represented by **sarcomas** and secondary **carcinomas.** The most commonly observed are the sarcomas, originating either in the medullary structure, in the periosteum, or in the immediately adjacent soft parts. The operative indication for these conditions is amputation or disarticulation. The bone that is the seat of the disease, together with its attached soft parts, must be entirely removed. Even this does not give immunity against recurrence. The prognosis in the **sarcoma of pregnancy** is much more favorable. Recurrence, except in subsequent pregnancy, is not frequent. In **epulis** at the alveolar processes of the jaw resection of the portion of jaw gives favorable results.

Fibromas of bone are comparatively rare and indicate extirpation of the tumor. **Echinococci** of bone are exceedingly rare; they require incision and extirpation of the sac.

OPERATIONS ON JOINTS

Operations on Joints after Injury.—**Puncture of the capsule** is sometimes required in **hemarthrosis,** particularly in that of the knee-joint occurring in fracture of the patella, the repair of the latter being facilitated thereby. Usually, however, the effused blood is resorbed without difficulty. In **hydrarthrosis** puncture of a joint is more frequently required. The operation should always be performed under the most stringent asepsis. If there is not much tension present, the left hand of the operator forces as much as

possible of the fluid in the joint toward the place of intended puncture. The trocar employed should be sufficiently large to permit the free passage of thickened synovia. If antiseptic irrigation of the joint is indicated, this can be accomplished through the trocar, solutions of carbolic acid (1 : 40), corrosive sublimate (1 : 2000), or salicylic acid (1 : 200) being employed. The irrigating fluid is forced into all parts of the joint by external manipulations and the joint thoroughly washed out by repeatedly filling and emptying it.

Incision and Drainage of Joints.—These two procedures combined are most frequently indicated by the occurrence of **suppuration of joints** after traumatism and infection, suppuration from any other cause (**pyarthrosis** from **polyarthritis, synovitis, gonococcus infection**), or from an extension of an **acute osteomyelitis** to an adjacent joint. In **granular synovitis** (**tuberculous**) the procedure is useless.

The first incision must be sufficiently long to permit digital exploration of the joint. Other and smaller openings (counter-openings) may be made when the condition of the joint is ascertained. The exploration should take cognizance of the condition of the cartilages with reference to the presence of necrosis; of the bone with reference to the presence of fissures or splintered fragments, sequestra, etc.; it likewise determines the most available points for locating the counter-openings. Dressing forceps introduced into the joint and their blades then separated form the best guide on which to make the incisions for the counter-openings. They are likewise utilized by being passed through the incision for the purpose of drawing the drainage-tube into position.

In large joints and extensive suppuration through-and-through drainage is best, a long tube being led through the whole joint cavity.

The attempt to drain a joint by means of a rubber drainage-tube introduced through the cannula employed in making a puncture is not to be recommended.

Incision alone may be employed for **diagnostic purposes,** but should be restricted to conditions in which strict asepsis is possible and where the incision may be utilized for therapeutic purposes. The operation is also indicated for the removal of **joint villi** and **free movable bodies** in the joint.

Resection of Joints.—The general indications for resection of joints are as follows:

1. **Compound dislocations.** Here the choice will be between removal of splintered portions, reduction of the dislocation and drainage, or **primary resection.** The circumstances in each case must be carefully taken into account, particularly with reference to the establishment and maintenance of aseptic conditions.

2. **Extensive and severe suppurative conditions consequent on injury.** Resections performed under these circumstances are either **intermediate** or **secondary,** according to the period of time intervening between the injury and their performance.

3. **Suppuration** occurring in connection with **tuberculous synovitis and myelitis.** While it cannot be said that every tuberculous focus in joints demands operative interference, owing to the fact that the suppurative process tends to limit the specific infection, greater security against general infection is obtained, other things being equal, by resection of the parts containing the tuberculous focus. Even after apparent recovery in cases not operated on, recurrence is to be feared.

4. **Granular synovitis without suppuration,** nonoperative treatment proving unavailing, furnishes an indication for resection. The presence of **granular myelitis** is an indication for **early resection,** a better functional result following this than when the interference is delayed, inasmuch as the sheaths of the tendons are still unchanged and the nutrition of the muscles comparatively unimpaired. Arthrectomy (*vide infra*) is followed by prompt and satisfactory results, in cases of synovial tuberculosis, pure and simple.

5. **Contractures and ankylosis,** in case nonoperative treatment is of no avail, may be submitted to resection. In **ankylosis** a most positive indication is offered by a functionally **useless position** of the parts, *e. g.*, a knee-joint in the flexed position, or an elbow-joint in the extended position. **Old dislocations,** if they cannot be reduced in the ordinary manner, require resection, both to increase the range of movement and to relieve functional dislocations arising from pressure. **Arthrodesis,** designed to produce a rigid condition of the joint in certain muscular paralyses and flail-like joints (infantile paralysis), involves resection of the joint surfaces (see page 373).

The justification for the performance of resection for the sole purpose of restoring function to otherwise useless parts is to be sought for, in each individual case, in the desire on the part of the patient to have his condition improved, and in a prior understanding as to all possible results of the operation itself.

Immediate resection is rarely performed in grave injuries. The opportunities of combating sepsis justify waiting for shock to subside. **Primary resection** is performed after the shock of the injury has subsided and before septic complications set in. This period covers from twenty-four to forty-eight hours after the injury. **Intermediate resection** is preferred after septic complications have set in and while these are in existence. By facilitating drainage and rendering accessible remote suppurating foci and collections of pus, resection in this period assists in overcoming sepsis. **Secondary resection** is performed after sepsis subsides. Its uses are to remove diseased bone; to overcome deformity; to relieve extreme pain or loss of function in a part. It may likewise be necessary because of the presence of persistent sinuses.

Partial Resection.—Many surgeons prefer partial resection. This may be indicated in certain **acute joint injuries** under conditions where an aseptic wound course may be confidently expected. Even here, the projecting articular extremity of the bone into the cavity, as, for instance, the presence of the lower extremity of the femur after removal of the head of the tibia, and of the humerus after removal of the ulna, may interfere with free drainage and aseptic treatment. Partial resection is not admissible as an **intermediate** or **secondary** operation and it is usually contraindicated in **granular synovitis** and **myelitis.** In the majority of instances it will therefore give way to total resection.

Erasion or **arthrectomy** (V o l k m a n n) is a variety of partial resection. It consists in opening the joint and cutting or scraping away all diseased tissues, these including both the synovial structures and the joint ends themselves. It is particularly applicable to the cases of tuberculous joint disease of childhood in which the granulating inflammation takes its origin in the synovial structure and is limited to that membrane. In this class of cases total resection, by interfering with the epiphysis, restricts the relative growth of the corresponding

limb. Special care must be exercised in selecting cases for erasion, in order that prompt and repeated recurrence may be avoided.

The General Technic of Joint Resection.—Incisions in the soft parts are usually made in the longitudinal axis of the limb and are so located as to avoid injury to tendinous and muscular structures. This rule may be deviated from at times in cases of granulating synovitis and myelitis, and particularly in resection of the head of the humerus and of the femur.

The parts are incised by a knife with a broad blade and a large handle. Large nerve-trunks and important blood-vessels are to be avoided. The drains are so located as to reach the deepest portion of the wound cavity and are placed in a position in which gravity will assist in carrying off the wound secretions.

When the resection is performed for granulating synovitis and myelitis, the capsular covering is necessarily sacrificed. Where the capsule is healthy, one or two longitudinal incisions are to be made in the synovial membrane; this is dissected loose and turned aside to permit the sawing away of the bone underneath (**subcapsular resection**). Further, **subperiosteal resection** is likewise to be employed wherever practicable. In the latter the periosteal covering is to be incised and turned back in the shape of a cuff to the extent of the intended removal of bone. The adjoining muscular and tendinous structures should be preserved in their attachment to the periosteum as far as possible. In cases of old inflammation this is comparatively easily accomplished. In recent injuries, old luxations, and ankylosis cases it is not possible, oftentimes, to make a completely subperiosteal resection. In these difficult cases it is occasionally possible to lift a layer of the outer lamella of the bone with the periosteum. When it is borne in mind that subperiosteal resection preserves the branches of the rete arteriosum of joints, prevents suppuration in the synovial sheaths of the tendons, as well as in the connective-tissue planes in the neighborhood of the joint, and secures the formation of new articular extremities, the necessity of adopting it in every case in which it is indicated or possible is apparent. Every strip of periosteum capable of being utilized should be preserved. Bony prominences which serve as attachments for muscles may be chiseled off and left attached to the latter.

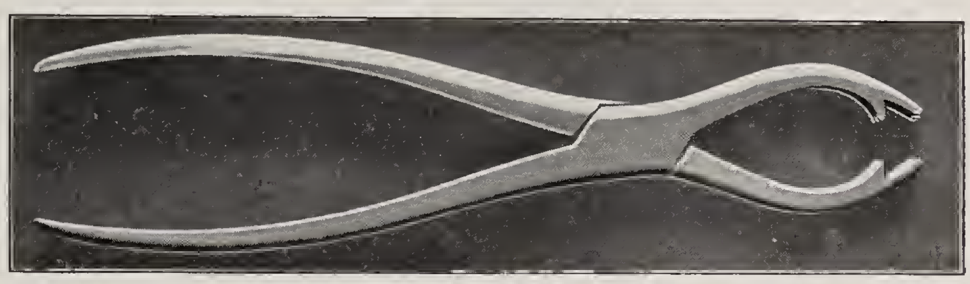


Fig. 161.—Lion-jaw Forceps.

The metacarpal saw (Fig. 148) is a very useful instrument for dividing the bone in resection of joints. Where sufficient retraction of the soft parts can be secured, either the broad or the frame saw (Figs. 82 and 83) is advantageously employed. The **chain saw** (Fig. 145) is not often used on account of the difficulty of carrying it around the joint extremities. In very young children the soft bone may be cut with a stout knife. It is sometimes an advantage to grasp the end of the bone about to be sawed off by means of the lion-jaw forceps of Ferguson (Fig. 161).

The extent of the removal of bone will depend on the conditions present.

In typic resection enough is removed to take away the joint cartilages. The extent of the resection also differs in different bones (see Regional Surgery).

In the case of the knee-joint a rigid though straight limb is aimed at. In the upper extremity a mobile connection in the joint is desirable. In the first instance, therefore, the simple sawing through of the line of fusion, or near the same, is sufficient. In **osteotomy** for the correction of contracture and ankylosis the bone is sawed or divided by the chisel two-thirds through and the remainder fractured. In the case of the elbow-joint, either the fused portions are at first separated and then isolated and removed, or the ankylosed portion is removed in a wedge-shaped piece.

Resection of Joints for Tuberculous Synovitis and Myelitis.—In civil practice joint resection is more frequently required for tuberculous affections than for traumatism. Here the resection must include the capsule, which is always diseased, as a routine measure. In fact, under these circumstances the operation becomes a typic extirpation of the entire diseased joint; this includes the removal of the entire synovialis, the sawing off of the joint ends and the articular cartilages, and the application of the sharp spoon to any suspicious point in the cancellous or medullary structure. In order to gain free access to the parts, large transverse incisions are made. In some localities it may become necessary to divide tendons in making these incisions, in which case these must be sutured at the close of the operation, in order to preserve their functions. In granulating myelitis the periosteum is not always involved; even considerable of the cortical lamella may be preserved, in which case the operation is completed by evidement (see page 369). Hemorrhage from the cancellous or medullary tissue is sometimes troublesome. In rare instances it may become necessary to apply the thermocautery for its arrest. Drainage of the medullary cavity, if deemed necessary, is secured by carrying a drain from the latter and either leading it through the external wound, or chiseling an opening in the cortical layer at a convenient point and thence through a separate incision in the soft parts. The employment of drainage is not always necessary, particularly if suppurative processes have not invaded the tuberculous affection.

If the operation has been thoroughly done, the **prognosis** is generally favorable, provided the patient is free from general infection. Recurrence may take place after the healing has been completed, or the wound surfaces themselves may become infected. The latter condition is known by a yellowish-brown and flabby appearance of the granulations lining the cavity and fistulous passages. As soon as these symptoms are observed, immediate steps should be taken to correct them. The sharp spoon or thermocautery is to be applied and the fistulous tracts opened up freely, if necessary to gain access to the infected granulations. These should be thoroughly curetted and the sinus injected with pure carbolic acid, followed at the end of a minute with 95 per cent alcohol. If the curetting has been thoroughly done and further packing of the sinus omitted, prompt healing follows in many cases.

The After-treatment of Resection Wounds.—The parts are to be enveloped in copious dressings of aseptic gauze. If drainage has been employed, these should be specially thick in the neighborhood where the tubes emerge. The large and dense dressings, reinforced by thin basswood or pasteboard splints, which should extend beyond the next adjacent joint and be secured in position by starched gauze (crinoline) bandages, first wetted and then applied,

will secure sufficient immobilization of the parts for the first few weeks at least, without the aid of plaster-of-Paris. The ordinary rules governing redressing should be followed (see page 57).

If all goes well a large resection wound may heal by primary union, except, in cases in which drainage is employed, the points where the drains emerge. Even in the knee-joint no more time is occupied in uncomplicated cases than is necessary for recovery from a fracture.

As the wound approaches complete healing, the surgeon's chief efforts should be directed toward securing the desired **functional result.** In the lower extremity solid union is to be obtained, and with this in view a fixed form of dressing, such as will permit the application of aseptic measures and at the same time completely immobilize the parts, is to be applied. The bracketed splint (Fig. 162), employed in connection with a plaster-of-Paris bandage, serves the purpose admirably.

In the case of the upper extremity, if a subcapsular and subperiosteal resection has been possible, not much difficulty will be experienced in obtaining an artificial joint (**nearthrosis**). The new bone is molded into shape and even articular extremities may form. Passive motion in the normal range of the limb will assist in the molding process. The synovial membrane resumes its function.

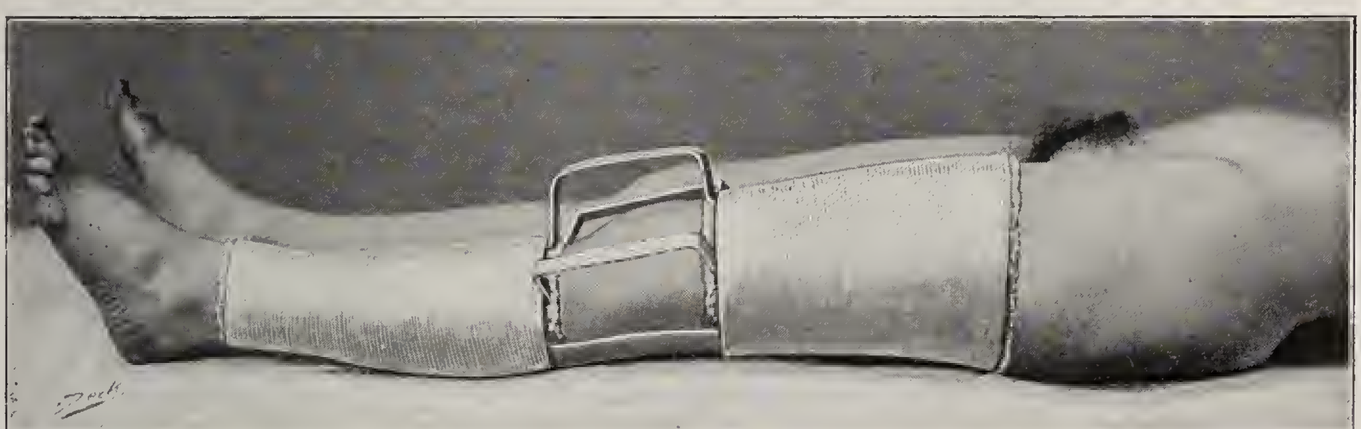


Fig. 162.—Bracketed Plaster-of-Paris Splint for Use after Resection of the Knee-joint.

In due time active movements supplement those of a passive character. Atrophy of the muscles resulting from nonuse is to be treated first by the galvanic current, and subsequently by faradization.

When it is found impossible to preserve the synovial capsule and periosteum, an artificial joint may still be secured. The perisynovial connective tissue seems to assume the function of the synovial membrane. Aseptic healing materially aids in producing a nearthrosis, even where no passive movements are made. But **flail-like joints** may result from excessive mobility, the joint permitting movements in all directions like a flail. This condition may arise from injury to important muscles by the incisions, defective preservation of the periosteum, severe and prolonged suppuration, the removal of too much bone and excessive passive movements during the after-treatment, and insufficient stimulation of the muscular apparatus, paralysis of the latter from nerve injury, and paresis of the same from want of use.

In the case of the elbow-joint a flail-like joint is of not infrequent occurrence after resection for tuberculous disease. Under these circumstances it is recommended to attempt to secure bony ankylosis in a proper position (Billroth).

Solid or **ankylotic union** must be secured at the knee and ankle; and even at the hip it is not a great disadvantage. Good functional results have been obtained, however, with an artificial hip-joint. Whether solid union is intended or not, in case of its occurrence the limb is to be placed in a position most convenient for use, *i. e.*, the elbow at a right angle and the knee in the extended position.

During the period of childhood every effort should be made to preserve the epiphysial cartilages in resection of the joints. Injury of these structures, with the enforced rest necessary in resection, leads to lessened longitudinal growth of the bone and consequent relative shortening of the limb.

Operations for the Removal of Joint Tumors.—**Movable or free bodies** in the joints (page 162) are now generally removed by means of incision of the joint (arthrotomy). This operation, in preaseptic times an exceedingly dangerous one, is now performed aseptically with the best results. The methods formerly in vogue, *e. g.*, the subcutaneous opening of the capsule and the forcing of the body out of the joint into the perisynovial connective tissue, from which point, after the wound in the capsule was healed, it was removed by open incision, the pinning of its free border to cause its adhesion, etc., are no longer necessary, provided a rigid enforcement of aseptic principles accompanies open incision and immediate extraction.

Difficulty is sometimes experienced in locating the movable body. If the symptoms are sufficiently urgent, exploration of the joint is indicated, or even resection may be resorted to.

Sarcoma, having its origin in the medullary structure, is the most important form of tumor of joints. While amputation above the joint has been resorted to, the operation of choice is disarticulation at the joint next nearest the body. Recurrences are not uncommon even then. Resection is absolutely excluded. **Sarcoma of the synovial membrane** is very rare. It tends to recurrence, as sarcomas elsewhere, and requires the same radical treatment as that springing from the bone itself. **Lipomatous** and large **papillary proliferations** of the synovialis are benign growths and do not necessarily demand interference. Extirpation of the growths is indicated, however, if their presence gives rise to functional disturbance.

AMPUTATIONS AND DISARTICULATIONS

Amputation and disarticulation differ from each other in the method of separation of the bones. The first has been termed **amputation in continuity,** the latter **amputation in contiguity.** Both are employed to follow the same general indications.

Indications.—Conservative surgery has very greatly restricted the indications for amputation and disarticulation. The following formal statement of these can therefore have but a relative value:

1. **Cases of Injury.**—Removal of the extremity is indicated in the complete crushing of a portion of the extremity, as in severe machinery accidents, shell explosions, etc.; in rupture of important vessels and injury of large nerve-trunks; in unsuccessful ligation of artery or vein or both; extensive rupture of tendons and muscles, in which the dangers attending the attempt to save the limb are very great and the usefulness of the limb itself but problematic.

at best. The crushing of bones and joints alone does not necessarily indicate removal of the limb; resection at joints and in continuity will frequently preserve an extremity thus injured. But this, combined with extensive injury to the muscles, tendons, vessels and nerves, such, for instance, as usually happens when a railway car passes over the limb, presents almost an absolute indication for amputation or disarticulation. This should be performed as soon as the patient rallies sufficiently from the shock to bear the anesthetic (**primary amputation**).

2. **Acute Inflammation.**—Removal of a limb may be indicated by the occurrence of acute inflammatory processes, when these cannot be controlled by antiseptic measures and the septic conditions are such as to threaten life. Again, when the local inflammatory processes are such as to render the extremity functionally useless, an indication exists for its removal.

3. **Chronic Inflammation.**—Tuberculosis of bones and joints furnishes by far the greatest number of cases in this class. Removal of the limb may be necessary to prevent general infection, or to rid the patient of a member practically useless, which is weakening him and exposing him to the unfavorable influences of intercurrent or secondary affections (*e. g.*, amyloid disease of internal organs). While resection of joints offers a conservative method of treatment in many of these cases, those in which tuberculosis of the lungs, kidneys, or bowels exists do better with amputation. Cases of extensive tuberculous disease of the wrist-joint, knee-joint, and ankle-joint require amputation rather more frequently in adults than in children, resection failing.

4. **Extensive destruction of tissue** other than that mentioned as resulting from mechanic disturbances may require removal of an extremity. In this class belong cases of gangrenous inflammation from extensive burns and frost-bite of the third degree, as well as senile gangrene and gangrene from venous stasis. Further, hospital gangrene and malignant edema are to be mentioned.

5. **Tumors.**—Malignant tumors of the soft parts, such as sarcomas of the skin and epithelial carcinomas, as well as benign tumors which tend to ulcerate or involve new portions of surface, such as elephantiasis, and are not amenable to other treatment, require amputation or disarticulation. **Malignant tumors of bone** demand removal of the extremity rather than resection.

Methods of Amputation and Disarticulation.—Three methods of separation of the soft parts are employed, namely, **circular incisions, flap amputation, and oval amputation.** None of the methods about to be described can be said to possess such decided advantages as to be employed to the exclusion of the others. The method is to be selected with a view (1) to the anatomic peculiarities of the region involved in the disease or injury; (2) to the character of the tissues, their freedom from disease or the extent of injury in which they are involved. It sometimes happens that the crushed and mangled tissues occupy but one side of the limb, and a large amount of healthy structure must be sacrificed if a circular amputation is insisted on. But if the flaps are fashioned in unequal lengths, or an oval amputation is selected, the healthy structure may be preserved.

Circular incision is the simplest of all methods of amputation. The skin is divided at one level, a cuff turned back, the muscles divided to the bone, and a cuff of periosteum fashioned by peeling this from the bone. The soft parts are now retracted and the bone divided. In making the circular incision the long

amputating knife is grasped by the hand with its edge up. First the knife and forearm of the operator are carried *under* the limb, and then the knife over the limb in the position shown at "1" (Fig. 163). The heel of the blade is passed well into the soft parts of the limb and the knife swept around, assuming the different positions shown in the figure (Joseph D. Bryant). Slight to-and-fro sawing movements aid in the section.

In dissecting up the cuff of skin the edge of the scalpel must be directed away from the skin, in order to avoid injury to the vessels in this structure. A short cut on the posterior surface of the limb, made parallel to the long axis of the latter, facilitates the turning back of the cuff and affords a favorable point from which the drainage-tubes emerge. In case of difficulty in turning back the cuff, from the presence of cicatricial contraction, a similar vertical incision may be made on the anterior surface, the circular incision thus being converted into two quadrangular lateral flaps. The circular method is particularly applicable to the lower third of the leg, the lower third of the thigh, and the middle of the forearm. Where the skin and fascia are closely attached, there is no objection to including the latter in the cuff. The nutrition of the skin is thus better secured.

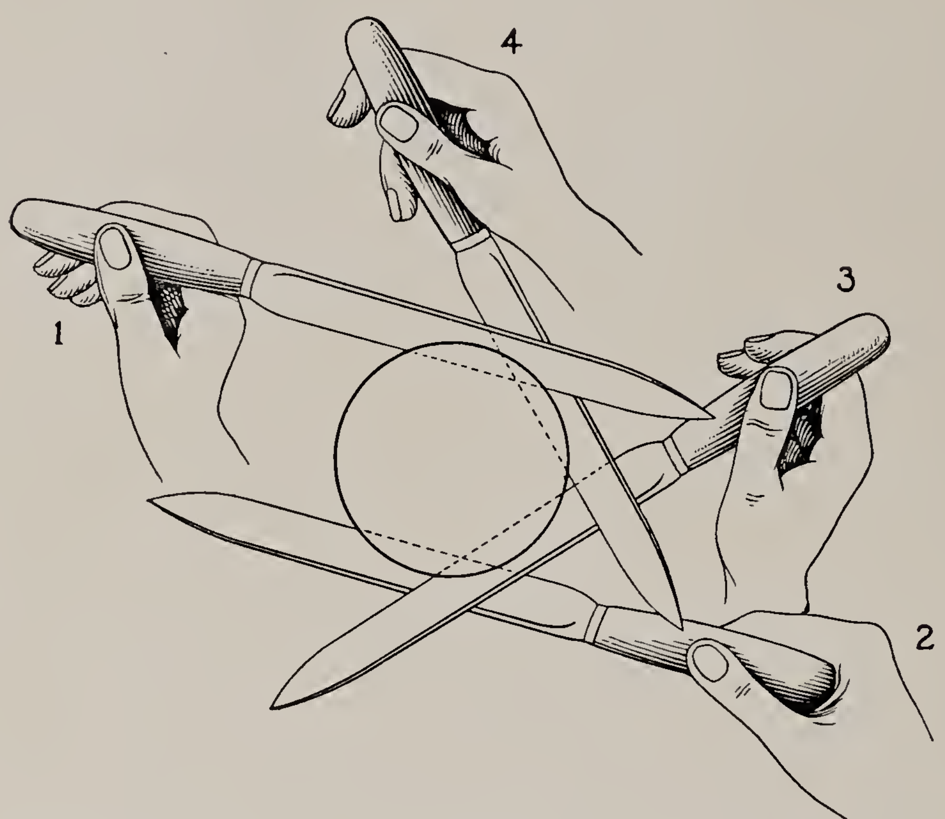


Fig. 163.—How to Carry the Knife Around the Limb in Amputation (after Bryant).

The length of the cylinder or cuff of skin will depend on the size of the limb. The incision through the skin should be placed at a distance below the proposed division of the bone corresponding to about one-fourth the circumference of the limb at that point. In making this incision the left hand of the operator should be placed above the line of section and the skin drawn in an upward direction. This compensates for the tendency of the skin to retract.

Flap Amputation.—Two methods are here employed. In the first the flaps are made by **incision,** while in the second they are made by **transfixion.** While the first has the advantage of permitting an accurate fashioning of the flap as to size, it has the disadvantage of producing a steplike shape to their surfaces, owing to the varying degrees of retraction of the different layers of muscular structures. The method of transfixion avoids this. The blade of a long amputation knife is passed through the limb at the base of the proposed flap, with its edge directed toward the apex of the latter. The knife hugs the bone at first, and with steady drawing movements the flap is formed, the edge being gradually directed anteriorly in the case of the anterior flap, and posteriorly in the case of the posterior flap. By this method the muscles, being made

tense in front of the knife, are divided more evenly. Care must be exercised not to make the flaps too long and narrow.

Examinations of old stumps show that the muscular tissues atrophy and that finally the ends of the bones are covered only by the integument and fascia. In amputation through healthy structures, therefore, the method of skin flaps will suffice, but in amputation through infiltrated or otherwise altered structures a larger blood-supply is assured to the skin by including the muscular and fascial structures in the flap.

The employment of methods of *unequal flaps,* as, for instance, in the operation in the lower third of the leg, known as Teale's, or that of one large curtain-shaped flap, as in the amputation of the thigh through the condyles (Carden), will depend partly on the parts involved in the operation, and partly on the injury or disease for which the amputation is performed.

Oval Amputation.—This method does not possess a wide range of application, yet it has some advantages in special cases. Where large muscular masses are to be divided, the individual groups are retracted in varying degrees, as in other methods. In oval incision the point of the oval is placed anteriorly where the retraction is the slightest, while the base is located at the point where the retracted muscular structures surround the bone accurately; a more even wound surface is thus produced. By this method the cicatrix can be made to assume a certain position, which is sometimes desirable, *e. g.,* on the dorsum, in amputation of the fingers, in order to assure the preservation of the tactile sense on the end of the stump, as well as at the palmar surface.

Choice between Amputation and Disarticulation.—When the choice lies between amputation and disarticulation, the following considerations should be borne in mind: Disarticulation is simpler; it requires only a knife for its performance; it does not open the medullary cavity and hence there is less risk of suppurative osteomyelitis; there are fewer structures opened up, the parts about joints being comparatively thin. On the other hand, these operations require greater anatomic knowledge and technical skill; portions of the synovial membrane are likely to be left behind and become subsequently inflamed; in case suppuration takes place, necrosis of the articular cartilages is liable to occur; the stump surface is very broad and requires large skin flaps to cover it in, which are not easily obtained in the region of joints; a number of tendons are divided, and the sheaths of these give ready access for suppurative processes to reach the tissues above the point of operation. In addition, the field of disarticulation must necessarily be a restricted one, demanding, if placed arbitrarily above amputation in the choice, the sacrifice in many instances of healthy structures.

While, therefore, there are some advantages in disarticulation as compared with amputation, the latter under aseptic conditions will, as a rule, be the preferable procedure. Under certain circumstances, such as in Symes's amputation of the foot, the two are combined. The sawing off of the prominent portions of the articular surface in knee-joint disarticulation has also found favor.

General Rules for the Performance of Amputation.—The incision in the soft parts should be made in healthy tissue, when possible. When tissues are devitalized by the presence of acute injuries, cicatricial conditions or edema, care must be exercised that the slightest possible traumatism is inflicted during

the operation. If suppuration is already present, vigorous antiseptic measures must be instituted.

The separation of the muscles is to be effected by long and decided strokes of the amputating knife. The intermuscular connective-tissue spaces must not be opened up more than is necessary.

Before the bone is sawed through a cylinder of periosteum must be peeled off from the part to be removed and pushed back with the soft parts of the stump. In some localities, as, for instance, the lower third of the tibia, and the femur, the deeper muscles and the periosteum are together detached from the bone with advantage.

Careful retraction of the soft parts by means of a broad bandage or the fingers of an assistant, whenever practicable, is necessary in order to avoid injury of these by the saw.

Splintering the bone, when the saw is nearly through, is to be carefully avoided by proper support of the part to be removed. Likewise, pinching the saw is to be guarded against (see page 363).

When two bones are to be sawed through, both may be sawed simultaneously until the larger of the two is divided about one-third of the way through; section of the smaller one is then to be completed, final division of the larger one following. The somewhat roughened point which marks the site of the completion of the work of the saw is rounded off with a rongeur (Fig. 90, A).

Hemostasis in Amputation and Disarticulation.—Exsanguination is to be accomplished preliminarily by elevation of the limb, and the application of a roller bandage or of Esmarch's rubber bandage. Compression, either by the fingers or by means of a Petit's tourniquet or the rubber bandage, secures against active hemorrhage during the operation (see pages 336 and 338). The separation of the extremity being accomplished, the larger vessels are secured by hemostatic forceps (see page 340) before the tourniquet or constricting band is removed; the latter is then temporarily relaxed and the smaller vessels secured. Catgut is to be employed for ligatures. Parenchymatous oozing is to be arrested by means of a large compress or towel wrung out of hot sterilized water.

In cases in which the vessels are the seat of atheromatous changes, floss silk (Ballance and Edmunds) may be applied; portions of the surrounding soft parts may be included by a circumsuture (see page 341). Vessels lying closely on the bone, as well as those difficult to grasp from any reason, may also be dealt with by the circumsuture.

Drainage, Suture, and Dressing after Amputation.—When drainage is employed, two or more rubber tube drains are to be placed between the sutures. These should be sufficiently long to insure efficient drainage of the wound surfaces of the stump. The tubes are secured from slipping inside the wound cavity by a safety-pin. Where septic conditions are already present, vigorous antiseptic irrigation by means of a 1 : 2000 solution of mercuric chlorid should be employed and the suturing omitted altogether. The drainage is secured by lightly packing the wound with gauze wet with a 1 : 2000 solution of mercuric chlorid in 50 per cent alcohol (equal parts of a 1 : 1000 solution of mercuric chlorid and alcohol).

The dressings are applied in such a manner as to make but slight compression.

the stump. A compress of heat-sterilized gauze should be applied over the line of sutures. Over this a number of two-yard square sterile gauze compresses, either heat-sterilized or wrung out of a 1 : 1000 freshly made sublimate solution, crumpled and evenly distributed over the parts, are placed. Finally, a covering of heat-sterilized nonabsorbent cotton batting, secured by roller bandages, completes the dressing. Sliding of the dressings is prevented by including the next adjacent joint in the dressings, applying a light splint to maintain this in position, and, just before applying the last turns of the roller, passing a broad strip of adhesive plaster down the limb parallel to its long axis, across the face of the stump and up on the other side. Undue retraction of the soft parts, which occasionally occurs in amputations of the thigh, may be prevented by preliminary division of the lower attachments of the muscles (Dawbarn), or by a traction strip of plaster, arranged stirrup fashion and attached to a weight and pulley extension.

The stump is placed in an elevated position to favor the return of blood from it, and steadied by long sand pillows, placed on each side to aid in preventing the painful muscular contractions which occur during the first few days.

Sequels of Amputation.—The sloughing of the flaps in cases of endarteritis cannot always be avoided. It is specially liable to follow amputation for senile gangrene. The employment of insufficient flaps, or their subsequent sloughing from any cause, notably the "buttonholing" of these during the operation, may lead to **conical stump.** This may also result from **intermuscular suppuration,** as well as from contracted and elastic conditions of the soft parts, and from **growth of the bone** in young subjects. Conical stump may sometimes be prevented, when threatened by retraction of the soft parts, by the application of a broad strip of adhesive plaster applied stirrup fashion, and weight and pulley extension. When due to growth of bone, **reamputation** or **subperiosteal resection of the bone** is necessary. This may also be required by extensive sloughing of the flaps.

Attachment of the cicatrix of the skin to the sawed surface of the bone, formerly a very annoying sequel, is not so frequently observed as it was before the aseptic era. **Eccentric pains** referable to the fingers or toes of the amputated member are sometimes very annoying. These gradually disappear. **Cicatricial constriction** of the nerve ends must be guarded against by removing considerable portions of the nerve-trunk and securing rapid and aseptic healing. The formation of neuromas is to be guarded against in the same manner. These latter produce violent pains and require excision.

Finally, **necrosis of the sawed surfaces of bone** may occur later on, due to suppurative periostitis and myelitis. The sequestra are to be removed from the direction of the stump. It is needless to say that, with aseptic and antiseptic methods, this is a rare sequel.

Common Amputation Errors.—**Sloughing,** or **suppuration,** or both, may occur if the flaps are made from tissues damaged by injury.

In **malignant disease,** failure to remove the parts well beyond the limits of the disease will result in a return of the disease in the stump.

In **senile gangrene** it will not suffice simply to remove the gangrenous parts. The adjoining tissues, though not actually invaded, possess but a slight

degree of vital resistance, owing to either insufficient vascular supply or trophic disturbances of nervous origin, such as **perforating ulcer of the foot,** and are ready to break down under the influence of the disturbances produced by the knife.

In the **dry gangrene** present in Reynaud's disease amputation of the diseased fingers or toes is frequently followed by destruction of adjoining tissues, which may live if left undisturbed. Septic conditions, however, are rare, under these circumstances. The failure depends on the fact that the surgeon's knife cannot remove the vasomotor spasm, on which the gangrene depends.

In amputation for **chronic joint disease** it is an error to make the flaps from edematous tissues, or those riddled with sinuses or the site of suppurative inflammatory processes. Under these circumstances the absence of the necessary recuperative power will frustrate the healing of the amputation wound.

Long disuse of a limb lessens the healing powers of its tissues. This is particularly true of limbs that have been long confined in splints, tightly bandaged, or kept in an elevated position.

In selecting the site of an amputation, failure to take into account **the patient's recuperative powers** may result in disaster. Primary healing should always be secured, if possible, in a patient already greatly weakened by disease or loss of blood, even if more of the limb is sacrificed than, under other circumstances, would seem to be necessary. At the same time the increased immediate risks of high over low amputations should be borne in mind.

To cut the **flaps too short,** and to be compelled to adjust these forcibly over the bone, is to invite final exposure of the latter, either from swelling and retraction, or from sloughing. The latter may likewise occur from rough handling of the flaps, separating the muscular tissues from the skin portion of the flaps while exposing the bone, or interfering unnecessarily with the blood-supply at the base of the flap.

In addition to **want of aseptic care** in the operative technic itself, **suppurative inflammatory processes** may result from injury to the soft parts by the teeth of the saw in dividing the bone; from forcing sawdust from the bone into the muscular structures; from including large masses of tissue in the ligatures; from permitting portions of tendons to project from the wound surfaces; from splintering the bone and leaving partially detached fragments behind; finally, from closing the wound before the bleeding has been thoroughly arrested and from too great tension on the sutures.

Failure to **dissect out the main nerve-trunk** from a long flap or to sever it at least an inch proximad to the level of the bone, in a circular amputation, may result in painful stump from involvement of the nerve in the cicatrix, or subsequent regeneration of the divided nerve (so-called stump neuroma).

SECTION XII

FOREIGN BODIES

Foreign Bodies and Their Effects.—Foreign bodies may become lodged in certain parts without injury to the tissues, such, for instance, as the esophagus, nasal cavity, auditory meatus, salivary ducts, larynx, trachea, vagina, and urethra. These will be considered in detail in connection with the diseases and injuries of these parts.

Foreign bodies in the tissues enter through solutions of continuity. In punctured and incised wounds the presence of a foreign body may result from the breaking off of the instrument itself, as, for instance, when a knife-blade becomes imbedded in the skull. Very brittle material forced into the tissues, such as glass, may also break off and remain as a foreign body.

The question of infection from the foreign body is an important one. In case this occurs suppuration necessarily follows and the foreign body is loosened and cast off with the pus; or it may be forced to the surface by the granulations which follow the suppurative inflammation. Wooden splinters invading the fingers, on account of their irregular surfaces most frequently follow this course if not promptly removed. In cases in which infection does not occur the foreign body, by contact with sensitive nerve filaments, produces more or less irritation and pain and requires removal.

Bullets and other lead projectiles may be clean of themselves, but infection occurs along their tracks from the presence of other foreign bodies, bits of clothing, etc., which have been carried into the tissues with the bullet. It is a mistake to suppose, however, that infected projectiles driven into the body by the explosion of gunpowder cannot carry infection on their own surfaces independently of that which they receive from passing through the clothing (LaGarde, U. S. Army). Though bullet wounds may be aseptic, this does not result from disinfection of the projectile by means of burning powder or from the passing of the projectile rapidly through the air, but rather because it was surgically clean beforehand.

Migration of foreign bodies may occur, as in the case of heavy lead balls in the substance of the brain and in the loose perimuscular connective tissue. In the first-named situation this migration is excessively dangerous. Slender and pointed foreign bodies, particularly needles, are sometimes driven onward by muscular contractions until they migrate to parts far distant from the point at which they entered. Serious consequences may follow their passage through important parts.

Solid products of living tissues may act as foreign bodies, such, for instance, as biliary calculi, vesical calculi, etc., which, by processes of ulceration, have left the viscus in which they originally formed and have become imbedded in the surrounding tissues, producing abscesses and fistulous openings.

Finally, the effects of foreign bodies will vary according to the mechanic,

chemic, or bacterial influences incident to their presence. They may likewise form the nucleus of calculi, when surrounded by physiologic secretions from which salts may be deposited (vesical and salivary calculi).

Diagnosis of Foreign Bodies.—When foreign bodies are superficially placed, their presence may be determined by the elevation of the overlying tissues. When they are situated in deep cavities or wounds, reflected light may be employed for diagnostic purposes. In the case of foreign bodies which arrest the **Röntgen ray** the presence of these may be determined by the shadow which they cast on the fluorescent screen; the portion of the body in which the foreign body is believed to have lodged is placed between the vacuum tube of the *x*-ray apparatus and the examiner. For purposes of permanent record the sensitized plate is employed in place of the fluorescent screen. This is afterward developed, as in ordinary photography. In employing **palpation** care should be taken to avoid pushing the foreign body still further into the tissues or other point of lodgment. When satisfactory evidence is not obtained by means of the finger, which is always to be preferred when available, instruments called probes are to be called into requisition. The wound may be enlarged to permit the passage of the finger. In cases in which the foreign body has been driven into the tissues with great force, as, for instance, a bullet, palpation may reveal the missile lodged at some distant point. In cases in which the bullet has followed the contour of the bony thoracic wall a line of tenderness may indicate its path.

FIG. 164.—TELEPHONE PROBE.

A, Receiver; B, flexible metal band for attaching receiver to the operator's head; C, flexible conducting cords; D, electrode to be placed in the mouth or rectum; E, screw connection for attaching probe; F, insulated portion of probe; G, noninsulated portion of probe.

Probes.—These are employed for diagnostic purposes, both in searching for foreign bodies in the tissues, and in cavities as well (*e. g.*, the bladder, etc.), and for determining the condition of bone at the bottom of suppurative fistulas connected with the osseous structure, as well as that of the walls of natural

canals (*e. g.*, lacrimal canal, esophagus, urethra, etc.). Bougies or sounds for special purposes will be described in their appropriate places.

In addition, specially constructed probes are used to follow sinuous tracks (vertebrated probe of Squire), and instruments of greater or lesser length with plain (not enameled) porcelain tip (Nélaton) for the exploration of gunshot wounds. In the case of the latter the porcelain tip receives and retains the lead marking made by contact with the bullet. In this connection is also to be mentioned the **telephone probe** (Girdner) for the detection of metallic foreign bodies in the tissues (Fig. 164). In using this instrument the aluminum bulb, D, is placed in the patient's mouth or rectum, the receiver, A, is held to the operator's ear, while the probe, FG, is passed into the wound in search of the bullet or other metallic foreign body. When the latter is touched, a peculiar grating or clicking sound is heard in the receiver. If the canal leading to the foreign body is tortuous and the probe cannot be made to follow this, a long steel needle is substituted for the probe and search made by passing this directly to the suspected locality. The probe or needle used for exploring should be insulated except at the tip, in order that the examiner may not be misled as to the depth at which the response to metallic contact is given.

Probes should be made of either virgin silver, copper, aluminum, or other flexible material, in order that they may be fashioned to follow the course of the fistulous track or wound. They are sometimes used as a guide in making

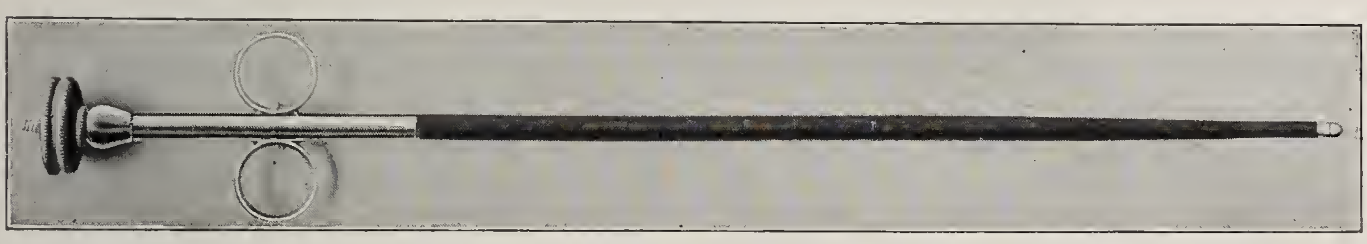


Fig. 165.—Elliot's Uterine Repositor Adapted as a Guide in Making Counter-openings.

counter-openings. The uterine repositor of Elliot (Fig. 165) has been adapted to this latter purpose (Hueter) by introducing it while straight and curving it in the required direction by turning the milled screw-head after it has reached the termination of the fistulous track to be opened.

The employment of probing as a means of diagnosis is frequently very unsatisfactory. The extremity of the probe can distinguish only a solid foreign body from the soft and yielding tissues. In the case of soft foreign bodies which are lodged in fibrous or otherwise unyielding structures it is quite useless. When a hard foreign body is lodged in unyielding tissue, *e. g.*, a splinter of glass lying against a phalanx, or a soft foreign body lies in yielding tissues, such as a bit of clothing in muscular structures, the difficulties are almost insurmountable. The only trustworthy form of probe yet devised is that employed for the detection of metallic foreign bodies (see telephone probe). Next to this is the porcelain-tipped probe of Nélaton (*vide supra*).

Removal of Foreign Bodies.—When accessible, foreign bodies should be removed at once, in order to escape possible septic infection. When deeply placed, their removal is not always an urgent necessity. The damage done by extensive exploratory procedures should be balanced against the possibly slight harm which may result from their continued presence in the tissues. Life may be threatened to such a degree as to demand that an attempt at extraction be

made. In furtherance of this, **trephining, tracheotomy** and **laryngotomy, cystotomy, urethrotomy,** or **gastrotomy** may be indicated in individual cases.

In case a foreign body is lodged in the skin or muscles, the ordinary dressing forceps or the dissecting forceps are usually sufficient for its removal. When convex surfaces of a foreign body present themselves, the forceps will slip, however, and even tend to drive it still more deeply into the tissues. This is particularly true when the foreign body is lying in a canal or cavity such as the urethra or nasal cavity. Under these circumstances a fenestrated spoon-shaped instrument, or a curet of proper size, is to be preferred. This is to be passed behind the foreign body and the latter scooped out, as it were. In the class of instruments which operate by being first passed behind the foreign body belong Graefe's coin extractor (Fig. 366) and the umbrella probang of Sayre (Figs. 368 and 369). (The removal of foreign bodies from special parts will be considered in Regional Surgery.) The removal of small and superficially placed iron splinters from the globe of the eye has been accomplished by means of a powerful magnet (Hirschberg).

Firearm Projectiles.—These are either cylindric, cylindroconic, elliptic, or acorn-shaped. The shape, however, after the discharge of the arm and entrance of the ball into the tissues, changes according to the density of the latter and to some extent according to the character of the rifling of the bore of the firearm.

Where but one opening exists, the ball is, as a rule, retained in the tissues. Exceptions to this, however, are to be noted in cases where the ball enters the cavity of the mouth or is swallowed, or enters a viscus, as the stomach, and is vomited, or the intestinal canal or esophagus and finds its way externally through normal channels. Again, a portion of clothing may be driven ahead of the ball in the case of a partially spent ball, and, not perforating the clothing, be removed from the wound of entrance by efforts made in undressing the patient. A careful examination of the clothing will eliminate the possibility of being misled by this. The passage of a ball by the same force along a natural canal after it is driven into the tissues is of rare occurrence. The existence of two openings denotes the occurrence of a complete perforation, as a rule, and the escape of the projectile, provided the occurrence of two shots or the existence of the fragment of a divided projectile can be excluded.

The wounds of entrance and exit differ from each other in most instances. The former is somewhat larger, more rounded and blackened and contused, as well as inverted. The latter is smaller, more oblong, and resembles a cleft with rather clean-cut and everted edges. Instances occur, however, in which these appearances cannot be relied on.

Recent **gunshot wounds** should be examined at once on account of the absence of swelling and sensibility. The strictest antiseptic precautions should be observed, whether the finger or the probe is employed. If hemorrhage is to be feared from the proximity of large vessels to the track of the bullet, the exploration may be omitted entirely until proper preparations have been made for its removal.

The advisability of making an attempt at removal of the bullet will depend on (1) whether or not it can be positively located; (2) the character of the tissues in which it has lodged. In case it cannot be discovered by the finger or probe, or the *x*-ray, it will usually be good surgery to permit it to remain

undisturbed. The occurrence of phlegmonous inflammation in case septic material has been carried along with the ball will disclose its presence. If none such occurs, in the great majority of cases no harm will result from its retention. Exceptions to this are to be noted, however, in cases in which grave functional disturbances occur from the presence of the missile in the brain, bladder, large joint cavities, etc.

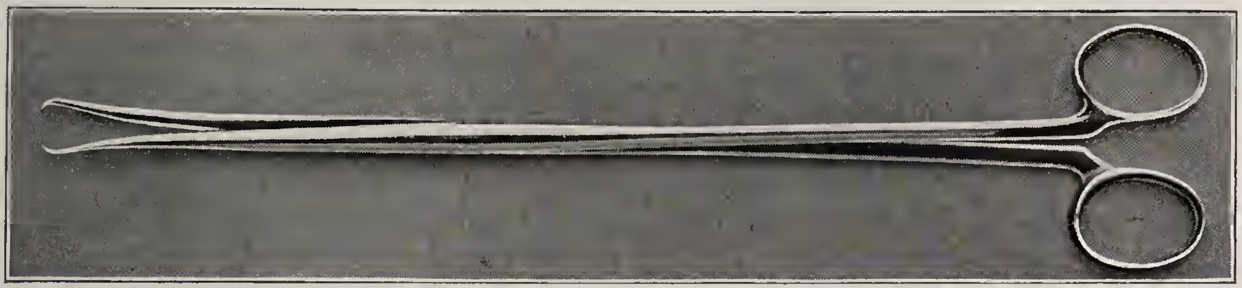


Fig. 166.—Tiemann's Bullet Forceps.

The removal is accomplished by instruments specially designed for the purpose. The most practicable of these are the Tiemann bullet forceps (Fig. 166). The instrument shown in Fig. 167 likewise serves a useful purpose.

In case no other foreign bodies, such as bits of clothing, etc., are carried into the tissues the wound will pursue, as a rule, an aseptic course. It is not possible, however, to determine this positively, and it will therefore be best to

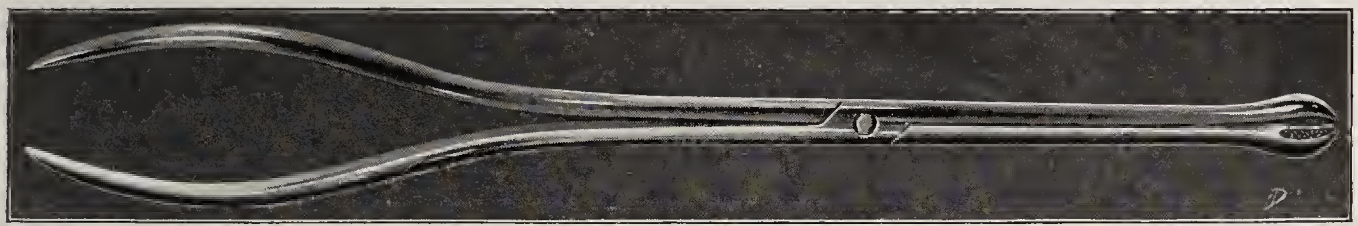


Fig. 167.—Bullet Forceps with Spoon-shaped Jaws.

drain the track of the bullet as a routine method of treatment and to adopt the most stringent antiseptic measures in the after-treatment. The treatment may therefore be summed up as follows: (1) removal of the infected foreign bodies; (2) cleansing of the accessible portion of the bullet-track; (3) drainage; (4) under certain circumstances dilatation or incision of the bullet-track, and counter-openings for through-and-through drainage.

SECTION XIII

BANDAGING

Materials.—Bandages are made of various materials according to the uses to which they are put. Bleached and unbleached muslin, linen, crinoline, Liverpool cloth, gauze and cheese-cloth, flannel, rubber, and various other materials are used.

Uses.—Bandages are used to retain dressings, as in case of wounds; to retain splints, as in fractures and dislocations; to make pressure, as in the palliative treatment of varicose veins and also in the treatment of tuberculous joints (Bier's method); to immobilize the parts, as in fractures, in which case plaster-of-Paris, paraffin, glass, starch or some other agent that quickly hardens is worked into the bandage; to arrest hemorrhage.

Classification.—Bandages are divided as follows: (1) the simple or roller bandage, which may be a single or a double roller; (2) compound bandages, which are also known as many-tailed bandages, and slings; (3) immobilizing bandages, commonly made of crinoline or other large meshed material into which plaster-of-Paris or starch has been incorporated. The form of bandage most frequently used is the roller bandage, which may be made of any of the materials above mentioned.

Fig. 168.—Rolling Bandage by Hand.

Strips of the selected material are cut, varying in width and length according to the locality to be bandaged. These strips are rolled up into a cylinder and constitute the roller bandage. This rolling may be done by hand or by means of a special machine devised for the purpose. If by hand, there are certain rules which, if adhered to, make the task an easy one. One end of the strip is first folded on itself a number of times until a small cylinder is formed. This cylinder is grasped by the right hand, the forefinger on one end, the thumb on the other, and while so held, revolved by the fingers of the other hand so as to roll around it the rest of the strip, which is guided by the left hand (Fig. 168). A simpler method and one which must be used if the width of the strip does not permit of its being grasped by the forefinger and thumb, is to start the cylinder as before, but instead of grasping it by the forefinger and thumb, to place it on the anterior surface of the thigh and roll toward the knee, tension being made on the

strip at the same time and care taken that each revolution of the latter accurately overlies the preceding one. If a machine is used, one end of the bandage is fastened by tension to the revolving spindle of the machine, and this, being turned by a crank, rapidly rolls up the strip. The propelling force of these machines may be the hand (Fig. 169), or the foot (Fig. 170). Also a machine may be so constructed as to roll a cylinder the width of the bolt of material, which may subsequently be cut into as many roller bandages as desired.

Fig. 169.—Hand Roller-bandage Machine.

For purposes of facilitating the description of the application of a roller bandage, the roller is divided into two parts. Thus, the free end is known as the **initial extremity,** the inclosed end as the **terminal extremity,** while all that portion between these two points is called the **body** of the bandage. There are also the external and internal surfaces. The double roller, less frequently used now than formerly, is made by sewing together the initial extremities of two single rollers. Compound bandages and immobilizing bandages will be treated of later.

Fig. 170.—Foot Roller-bandage Machine.

Dimensions.—The width and length of a bandage will vary according to the part to which it is applied and also according to the purpose for which it is used. In bandaging the fingers and toes, the inch-wide roller is to be preferred. In length this bandage varies from three to five yards, according to the variety to be used. The most useful bandages for the head and for the extremities in children are two inches wide and from four to seven yards long. Bandages two and a half to three inches wide and six to ten yards long are used for bandaging the extremities in adults and for thigh and groin bandages. In bandaging the trunk a roller four to six inches wide and six to eight yards long is most frequently used.

General Rules.—There are a few simple rules to be observed, the application of which in applying bandages will aid the beginner to master the art

more quickly. First, as to holding the bandage: It is best to grasp the roller tightly between the thumb and the finger, and to rest it in the hollow of the hand so that it will unroll easily. The internal surface of the roller bandage is the one that is external when it is applied to the part, and the external surface becomes internal. Second, in applying a bandage to an extremity, always cause the bandage when applied anteriorly to run away from the median line of the body. This should be borne in mind in reading descriptions of methods of bandaging. The turns should always be applied smoothly and with even pressure. In case of an extremity the roller should be applied from the toes or fingers, as the case may be, in an upward direction. Third, see that the part is in the position it is to retain after the bandage is applied, otherwise there may result pressure effects from the subsequently altered position. If bleached muslin bandages are wrung out of warm water, this will be found to facilitate their application. This rule is particularly useful in bandaging fingers. Fourth, in fastening a bandage use safety-pins or needle and thread, not plain pins; or tear the end longitudinally, knot to prevent tearing, encircle the part in opposite direction with the torn ends, and tie. Fifth, in removing bandages either cut or unwind them. If the bandage is to be cut, there are special scissors made for this purpose. These have a blunt point on one blade of the scissors which prevents the blade from injuring the patient while they are being used (Fig. 171). If a bandage is to be unwound, the unrolled portion should be loosely collected in the hand in a mass as the unwinding proceeds and the mass passed from one hand to the other, a rapid and neat removal of the bandage being thus effected. The removal of the plaster-of-Paris bandage will be discussed further on.

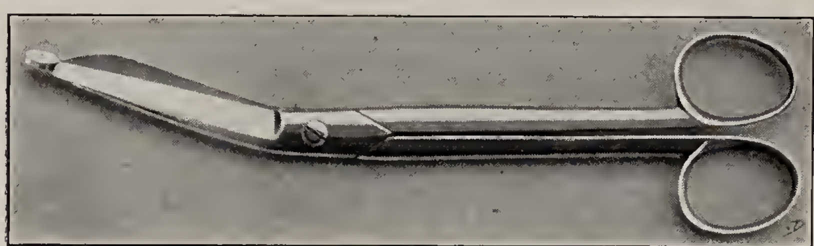


Fig. 171.—Bandage Scissors.

Varieties of Roller Bandages.—In roller bandages a number of "turns" are used. It is quite necessary to understand the nature of these turns before using them in any special bandage. Circular, spica, and spiral turns are used, together with several other varieties, and the bandage is known as a circular, a spica, or a spiral bandage, according to the kind of turn employed.

Fig. 172.—Circular Bandage.

Circular Bandages.—A circular bandage is made up of a number of circular turns, each turn accurately overlying the turn preceding it (Fig. 172). This bandage may be used to retain dressings on small wounds of circular portions of the body, as the head, upper arm, and neck, and for purposes of coaptation.

Oblique Bandages.—An oblique bandage is one in which the turn runs obliquely around a part without overlapping (Fig. 173). It is useful in applying temporary dressings.

Spiral Bandages.—In a spiral bandage the turns surround the part in a

spiral manner, each turn covering in one-half or more of the preceding turn. This form of bandage can be used on parts of the body which do not increase rapidly in circumference, as the finger, chest, and abdomen.

Reversed Spiral Bandages (Fig. 174).—When the part of the body to be bandaged increases rapidly in circumference, as in the case of the forearm of a well-nourished person, it is impracticable to continue the use of spiral turns, since they soon assume the shape of a simple oblique bandage and become easily disarranged; what is more important, they do not exert even pressure. To overcome this when a muslin bandage is used, the bandage is folded obliquely on itself, or reversed, in such a manner as to cause it to conform to the shape of the part. In making these reverses the forefinger of the left hand is placed on the previously applied turns to hold them in place and the head of the roller is turned toward the operator in such a manner that the slack of the bandage is turned or folded obliquely on itself, the part being thus fitted

Fig. 173.—Oblique Bandage.

Fig. 174.—The Reversed Spiral Bandage.

snugly (Fig. 174). As many of these reverses are applied as required, care being taken that the points of the reverses are in alignment and that they are smoothly applied; also that they do not lie over bony prominences, as the crest of the tibia, for here they may give rise to pressure effects. When a bandage is made of yielding material, the reverse may be made by simply changing the direction of the bandage in an alternating manner so as to

form a short figure-of-8. For instance, in bandaging the leg, instead of permitting the turns to pass at right angles to the limb, the turns are placed obliquely, the direction of the obliquity alternating at each turn. As the bandage passes in front of the limb it is directed obliquely upward; after it passes to the back of the limb and as it approaches the front from the other side, it is directed obliquely downward (Fig. 175).

Spica Bandages.—Spica turns are those which cross each other in the form of the capital Greek letter "lambda," thus Λ, and a bandage made up for the most part of these turns is called a spica bandage. They are useful in retaining dressings on the shoulder Fig. 211) and groin (Fig. 224) and also in exerting firm pressure.

Fig. 175.—Spiral Bandage with Alternating Obliquely Directed Turns (Short Figure-of-8).
The dotted lines represent the direction taken by the next turn of the bandage.

Figure-of-8 Bandages.—These bandages are made up of figure-of-8 turns, and are most frequently employed in the neighborhood of joints. A turn is first taken above the joint, and then another below it, a figure 8 being thus formed. The joints over which such turns are used are the elbow, wrist, knee, and ankle (Figs. 216, 217, 229, 230).

Recurrent Bandages.—Recurrent bandages are made up of turns which extend back and forth over a part until it is covered, these recurrent turns being secured by spiral turns. The bandage is used to cover in the ends of fingers or toes, and in the dressing of stumps (Fig. 176).

Pressure Bandages.—In cases where pressure is indicated, as in varicose conditions of the extremities, the treatment of tuberculous joints by blood stasis, to control effusions in joints and in the soft parts, and to control hemorrhage, the pressure exerted by the muslin roller is insufficient unless applied so tightly as to produce serious injury to the soft parts. For these purposes a bandage is needed which will combine elasticity with strength. Again, the amount of elasticity depends on the condition for which the bandage is employed. Bandages of stockinet, flannel, and rubber will be found to meet all the various indications. The **flannel bandage** is made and applied in the same manner as other roller bandages. It is useful in preventing and limiting the progress of effusions and also as a primary roller under the plaster bandage. In babies, and persons of irritable skin, so-called canton flannel may be employed. Stockinet and Japanese crêpe are expensive but extremely useful materials of which bandages for the treatment of varicose conditions may be made. They exert the needful amount of

uniform pressure and do not irritate the skin. The thickness, length, and width of the **rubber bandage** vary with the purpose for which it is employed. For simple pressure in cases of varicose veins, a thin bandage is used. For rendering an extremity bloodless (E s m a r c h) a thicker one is required. When the latter is not at hand, two thin rubber bandages rolled together answer the purpose. When employed to render a part bloodless, the rubber bandage is started at the distal end of the extremity and ascends with firm pressure in spiral turns. Each turn meets, but does not overlap, the preceding turn (Fig. 124). When a level has been reached well beyond the site of the proposed operation, a few circular turns are made. These circular turns are lifted up over the course of the main artery by the fingers of the left hand, while the fingers of the right hand thrust what remains of the body of the bandage vertically under these circular turns, and so effectually shut off all blood-supply. The spiral turns are now unwound and this part of the bandage placed loosely around the extremity at the level of the circular turns (Figs. 125 and 126). Care is taken not to place the circular turns at a point where they will cause serious pressure on important nerves. It is of extreme importance that no bandage of this kind be used in cases in which there is danger of pressing either tumor or septic products into the circulation. In such cases the bandage must be placed above the limits of the disease. The **rubber tourniquet** is a narrow, thick band having a chain attached to one end and hooks to the other, by which it may be secured; it is sometimes used to secure the tourniquet effect in place of the final circular turns. Tourniquets are also used for the immediate control of hemorrhage in accidents to the extremities.

Fig. 176.—Recurrent Bandage of Stump.

The chief **use of the rubber bandage** is in the treatment of varicosities of the lower extremity. It is applied with even pressure, beginning at the base of the toes, and in case of varicosity of the leg ending just below the knee. Should the varicosity also be present on the thigh, the bandage is continued upward to the groin. Reversed turns are not necessary, as the elasticity of the bandage allows it to conform to the shape of the extremity. It is fastened by means of two tapes attached to its distal end. These tapes are wound around the extremity and tied. While not a strictly curative measure, it relieves those cases for which it is indicated. The daily contact of the rubber will produce eczematous conditions in some individuals. To avoid this a thin flannel bandage is applied next the skin. The bandages should be removed at night when the patient has resumed the recumbent position, and reapplied in the morning before he arises. After removal they should be rinsed in lukewarm water and hung up in folds to dry.

For use in the B i e r treatment of tuberculous joints a much shorter ban-

dage can be employed. Half a dozen circular turns are all that are necessary. As this method is employed in children, whose skin is particularly prone to irritation, and as the rubber is to be kept applied for several hours at a time, it is well to protect the skin by the application of a few turns of a canton flannel bandage. The amount of compression necessary to produce venous stasis must be judged by the effect on the limb. A bluish "marbled" appearance is to be produced. The arterial blood-supply is not to be arrested. The parts below the diseased area are to be supported by a snugly applied roller bandage (Fig. 209).

FIG. 177.—PLASTER ROLLER-BANDAGE MACHINE.

Permanent Fixation Bandages.—The ordinary roller bandage, while it fixes the parts at the time it is applied, soon becomes loosened if the parts are moved. In cases which require absolute rest, therefore, we are obliged to incorporate into the bandage some material which will make it stiff, so as to secure immobilization of the parts and durability of the bandage. The uses of such bandages are manifold. They frequently take the place of ordinary splints. For purposes of stiffening, soluble glass, paraffin, starch, and plaster-of-Paris are most frequently employed. The starch bandage is made by soaking large meshed material in a strong solution of starch, then spreading it flat to dry. Bandages of various widths are made of thin material. When ready for use, the starch bandage is dipped in hot water for a few minutes or sufficiently long to allow the water to penetrate the innermost parts of the bandage. It is wrung out almost dry and applied as any other bandage. It soon dries, forming a firm protective splint, but it is neither so hard nor so durable as the plaster-of-Paris roller. It has the advantage, however, of being much lighter, and is therefore to be preferred in simple injuries of the upper extremity which require fixation, but the patient should be instructed to take special precautions against further injury. It may be removed by cutting with a knife, or with scissors if only a few layers have been used, or by unrolling.

Method of Preparation of Plaster-of-Paris Bandage.—An open-meshed material, such as "cross barred" crinoline, is selected for the bandage. This is cut the proper width and length, and rolled. This rolling may be done by hand or in any one of the numerous bandage boxes made for the purpose. As the bandage is being rolled, fine plaster-of-Paris (dental plaster) is rubbed in if the operation is carried on by hand; or allowed to fall in the turns of the bandage if a special machine is used (Fig. 177). When a bandage of the required length and width has thus been prepared, a small rubber elastic is snapped around it to keep it from unrolling, and it is wrapped in oiled paper or placed in an air-tight can to prevent the plaster from becoming moist and caking, which it is quite likely to do unless kept in a dry place. Made in this way, these plaster bandages may be kept indefinitely. Should they become damp at any time, they may be put in an oven and dried.

When they are required for use, the oiled paper is removed from a sufficient number of bandages of the proper width. These are placed on a table with a basin containing hot water. Table salt, in the proportion of one heaping teaspoonful to two quarts, added to the water is useful in hastening the hardening, but causes brittleness of the plaster cast after setting. Zinc oxid added to the water is also useful in facilitating the setting. The member to which the plaster is to be applied is to be thoroughly cleaned and shaved. It is now covered with a thickness of sheet wadding, applied as a roller bandage. Extra layers of cotton are placed over bony prominences, such as the olecranon, patella, and crest of the tibia. This is to prevent local gangrene of the skin overlying these points, from excessive pressure. In place of sheet wadding a thick canton flannel roller may be used. Whatever is used, its purpose is to transmit the pressure of the plaster equally, and to prevent direct pressure on the skin. Care must be taken not to cover the bony prominences with too much cotton in the endeavor to protect them, lest the purpose of the fixation bandage be nullified by allowing the parts to move inside it. Sometimes a plaster-of-Paris bandage is applied, allowed to harden, and then cut along each side and removed. It is then padded with cotton and reapplied as a **removable plaster-of-Paris splint.** In such cases sheet wadding or a canton flannel roller is not to be applied primarily, as an exact cast of the parts themselves is desired. To protect the skin from irritation and to facilitate the removal of the cast, vaselin is thickly coated over the entire surface which is to come in contact with the plaster.

When the skin and bony prominences are protected, two of the bandages are placed in the basin of hot water. These are left immersed until the water has penetrated to the core. The surplus water is expelled by squeezing the bandage by pressure on its sides. In order to save time, as one is taken from the basin another is placed therein until the required number is reached. The general rules which govern the application of other bandages apply also to the plaster roller. It is applied evenly, smoothly, and with uniform pressure. Those parts which are subjected to the most strain, as the elbow, knee, ankle, and other joints, are reinforced by supplementary turns of the roller. The number of layers applied depends on the purpose for which the bandage is employed. Simply to retain a dressing in place, two or three layers are all that are necessary. On the other hand, six to eight layers are necessary to insure immobility of joints. In the ambulatory treatment of fractures of the lower extremity (see page 136) more layers will be required than in case the patient

is to rest quietly in bed. If the bandage is used over a wound, as in compound fracture, a window or a fenestra may be cut through the entire thickness of the bandage. Should very large fenestrae be required, pieces of soft iron may be bent into the shape of the Greek letter Ω and used to reinforce the bandage. These fenestrae should be cut after the plaster has hardened, so as not to impair its strength. In order to produce a nice finish, the last plaster roller applied may have a selvage. This is so applied as to cover the raw edge at each successive turn and leave the selvage exposed. Dry plaster may be rubbed in after the bandage is complete. The parts must be kept perfectly quiet in the required position all through the application of the bandage and long enough afterward to allow the wet plaster to harden.

Removal of the Bandage.—In the case of the extremities, the line where the bandage is to be cut should be on the external surface, but many circumstances will govern this point, so that no hard and fast rule should be laid down. There are many appliances specially devised for the removal of plaster-of-Paris splints, such as knives and saws of different shapes (Fig. 178). A strong straight-bladed resection knife or a shoemaker's knife answers the purpose. The cut is to be made obliquely rather than at right angles to the surface. A

Fig. 178.—Removal of Plaster Splint with Plaster Saw.

weak solution of acetic acid (common vinegar) is painted along the proposed line of incision. This softens the plaster and makes it easier to cut. The bandage, or cast, as it is more commonly called, should be removed in one piece to avoid any unnecessary disturbance of the parts. Vinegar may be used to remove any plaster which has adhered to the hands. Water, to which either granulated sugar or molasses has been added, is also useful in removing plaster from the hands.

Dangers of the Plaster-of-Paris Bandage.—The dangers attending the application of an ordinary bandage are multiplied in the case of the plaster-of-Paris bandage. This is specially true in cases of recent fracture which have been immoblized in this way. At the first sign of superficial venous stasis the bandage is cut completely open from end to end; should the blood stasis not be relieved by this, the bandage must be entirely removed. All cases should be watched for the first few days following the application of the bandage. The danger of gangrene is always present.

Compound Bandages.—These are usually made of unbleached muslin, cut in various ways to form the shape of the part of the body to which they are to be applied. There is a great number of these bandages, but few of them

are really useful. Their true range of usefulness is limited to the hurried first dressing done on the battle-field. As a rule, they afford neither the comfort nor the security of the well-applied roller bandage.

The **sling** is one of the most frequently used of the compound bandages. It is made in three ways. Two of these are for the upper extremity and one for the lower. The former is a single triangle of muslin, or a yard square of muslin folded diagonally to form a triangle. The apex of the triangle is applied under the elbow, the half of the triangle which is next the body goes over the opposite shoulder, the other half of the triangle goes over the shoulder of the affected side. The ends of these two halves are knotted at the back of the neck, enough traction being put on each end to insure that the body of the triangle affords equal support for the entire length of the forearm. To afford additional security the two sides of the sling may be sewed or pinned together, parallel to

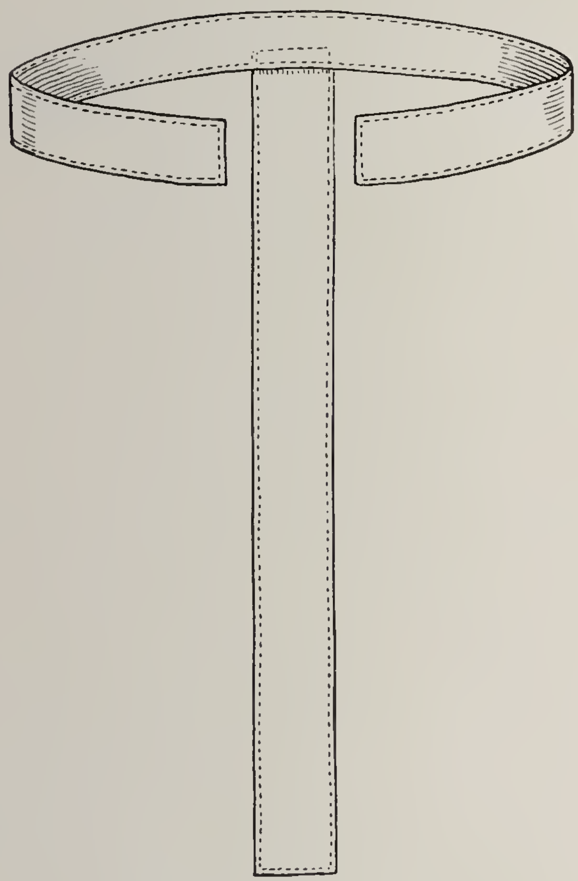


Fig. 179.—T-bandage.

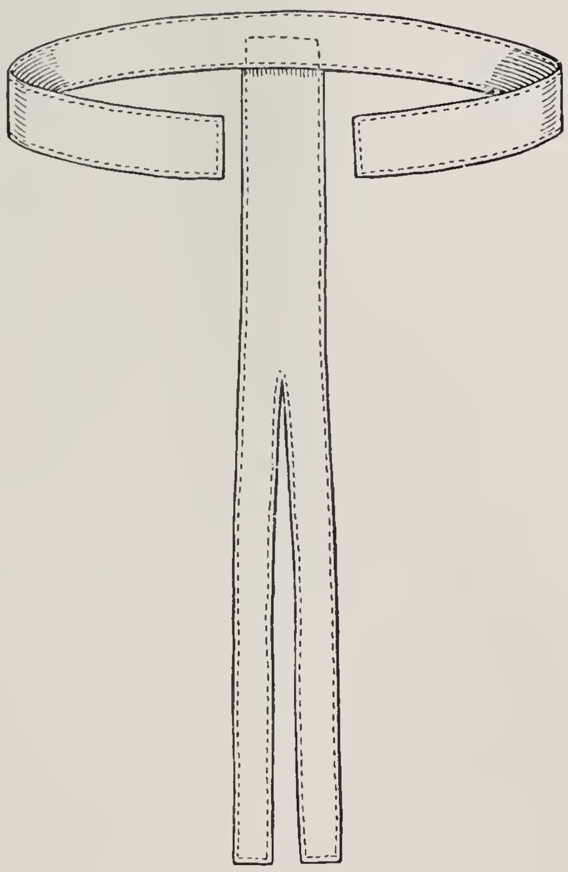


Fig. 180.—Double T-bandage.

the forearm and just above it. The apex of the triangle is pinned to the front of the sling. The second form for the upper extremity is used as a sling for the upper arm. It is of use only when the patient is in bed. A strip of muslin as broad as the arm is long and about three feet in length is used. One end is pinned along the median line of a previously applied bandage of the chest. The other end is passed between the body and the arm, partly surrounding the latter, and brought back to the starting-point, where it is pinned or sewed fast. It should be applied with just enough tension to support the arm comfortably. For the lower extremity a sling may sometimes be used with advantage in fractures of the femur. A long board splint, 10 inches broad and long enough to extend from the axilla to below the heel, is well padded and secured to the chest and pelvis by bandages or adhesive plaster. One of the long sides of a broad strip of muslin is tacked to the uppermost edge of that portion of the splint corresponding to the leg and thigh. The body

of the strip is then passed under the leg and thigh and fastened to the first edge, the whole thus forming a convenient sling.

The **single and double T-bandage** are both frequently used, the first to hold perineal dressings in place in the female, the second, in the male. These are called perineal T-bandages. They are made of a broad strip of muslin sufficiently long to encircle the pelvis. This is called the body of the bandage. To this is attached a narrow strip at the center of the body of the bandage to form the single T (Fig. 179). In case a double T is required (Fig. 180) two strips are fastened a short distance to each side of the middle of the body of the bandage.

T-bandages may be made of varying breadth and length of body and strips

Fig. 181.—The Chest "T"-binder.

so as to conform to different parts of the body. Examples of this are found in the chest T, the abdominal binder, and the breast binder.

In applying the **chest T,** the body of the bandage, 10 or 12 inches broad, surrounds the chest, while the vertical straps pass from behind over the shoulder and are fastened in front (Fig. 181). The plaited **abdominal binder** is from 12 to 18 inches wide and in length one and one-half times the circumference of the body. It is securely pinned in front with safety-pins and made to fit snugly by taking plaits on each side (Fig. 182). Straps of muslin are passed from behind forward over the perineum and fastened posteriorly and anteriorly to prevent any slipping of the bandage. These are called perineal straps. These are both fastened with safety-pins so as to admit of easy removal when soiled.

The **breast binder** (Fig. 183) is a modification of the T-bandage of the chest.

FIG. 182.—THE PLAITED ABDOMINAL BINDER.

It consists of one piece of doubled muslin made into an armless jacket. In

FIG. 183.—THE BREAST BINDER.

applying it, the portions which correspond to the straps of the T-bandage are fastened over each shoulder with safety-pins. The ends of the body of the

Fig. 184.—The Triangle of the Groin.

bandage are then secured to each other in front. A nice fit is obtained by taking plaits with safety-pins on each side.

Fig. 185.—Hernia Bandage.

Single and double T-bandages may be used to retain dressings on different parts of the head and face.

A variety of T-bandage known as the **triangle of the groin** is often useful. The vertical strap of the single T is made broad and triangular, the base of the triangle being attached to the body of the bandage. The portion of the body with the triangle attached is placed over the dressing to be retained. The ends of the body of the bandage are then fastened, while the apex of the triangle is drawn across the perineum to be attached to the body behind (Fig. 184).

A useful **hernia bandage** is made by lengthening this bandage so as to encircle the body twice, attaching the initial extremity of a roller 3 inches wide to the apex of the triangle and using this as a spica for the thigh and groin (Fig. 185).

The **four-tailed bandage** is a light and effective dressing for fracture of the lower jaw with slight displacement, and is also used to retain dressings in the region of the chin. A strip of bandage 4 inches broad and 3 feet long is

Fig. 186.—Four-tailed Bandage for the Jaw.

employed. Each end is split in two and torn longitudinally until within 4 inches of the middle of the bandage. This four-inch square is called the body of the bandage. The center of the body is applied to the symphysis of the jaw. The upper two of the four tails are carried directly backward to beneath the inion and are there drawn taut and knotted. The four loose ends are then tied tightly together and the superfluous ends cut away (Fig. 186).

Retractors.—These are bandages made by splitting strips of muslin six or eight inches wide into two or three tails, according as they are to be used for retracting the soft parts around one or two bones.

A **many-tailed bandage** is sometimes used to retain the dressings of an abdominal wound and to exert even pressure as the fluid is withdrawn in paracentesis abdominis. The body portion of the bandage occupies a little more than one-half of the circumference of the abdomen, the tail strips being supplied by tearing or splitting the remainder from the ends. The bandage is secured

in position by crossing the tail strips, drawing upon them until the bandage fits snugly and pinning the end of each separately at the sides (Fig. 187).

Adhesive Plaster.—Two varieties are furnished for the use of the surgeon, namely, the officinal **resin plaster** and that known as **rubber plaster** or **surgeon's adhesive plaster.**

FIG. 187.—MANY-TAILED BANDAGE FOR THE ABDOMEN.
The appearance of the bandage before application is shown in the upper right-hand corner of the illustration.

Uses.—Adhesive plaster is sometimes used to approximate the edges of superficial wounds, and occasionally the skin edges of deep wounds, when it is desirable to avoid the use of skin sutures. When used for this purpose, it should

FIG. 188.—THE FIRST PIECES OF DRESSING OF AN ABDOMINAL SECTION HELD IN PLACE BY ADHESIVE PLASTER AND TAPES.

be sterilized by passing the strip, cut ready for use, with its back down across the flame of a spirit lamp. Care should be taken not to apply the plaster too hot. When resin plaster is used, it will be necessary to heat it in order to make it adhere. When rubber plaster is used for purposes other than the above, it

will not require heating. In applying the plaster to the edge of a wound a space should be left between the strips for the escape of discharges.

It is sometimes necessary to secure dressings and bandages from slipping by the use of adhesive plaster. This is most frequently used in this connection for retaining the first pieces of dressing in position in the case of an abdominal section (Fig. 188). When bandages are liable to slip, as, for instance, in the thigh, a strip of adhesive plaster laid over the bandage on the inner and outer side is useful in holding the bandage in place.

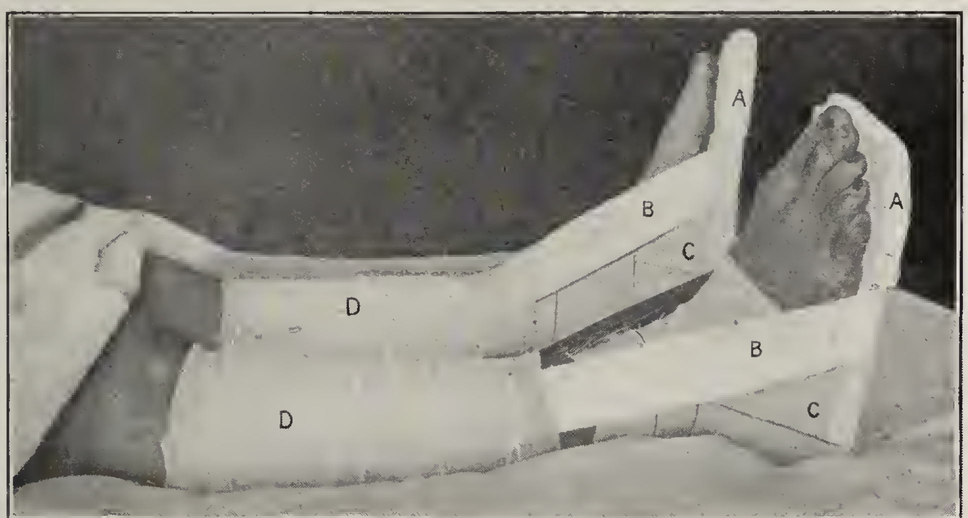


Fig. 189.—Stirrup of Adhesive Plaster to Prevent the Foot from Assuming the Equinus Position.

A, A, Padded foot-pieces; B, B, adhesive plaster straps; C, C, bandages securing foot-pieces in position; D, D, bandages securing upper ends of adhesive plaster straps.

Adhesive plaster is useful for retaining a graduated compress in position, and for exercising direct pressure as a local therapeutic measure, as in strapping a testicle and the female breast. It is likewise employed to secure the immobilization of parts, as in fractures of the ribs and sprains of joints, and to prevent the foot from assuming the equinus position when patients are long confined to the bed (Fig. 189). In the **ambulatory treatment of ulcer of the leg** adhesive plaster is useful to relieve the hyperemia of the parts. Resin plaster is to be preferred for this purpose.

Fig. 190.—Buck's Extension.

One of the most important uses of adhesive plaster is to furnish a means of **making extension on an extremity** for the purpose of maintaining the fragments in position after a fracture. It is most frequently employed for this purpose in fractures of the femur (Gurdon Buck). The adhesive plaster is cut so as to provide both longitudinally and obliquely placed strips (Fig. 190).

The parts to which adhesive plaster is to be applied should first be cleansed, and, if hairy, they should be shaved. In removing rubber plaster the latter may be loosened by the application of alcohol or benzin. The streaks of gum left at the site of the edges of the plaster may be removed by the use of the same agents. In making a second application of plaster care should be taken to avoid, if possible, the site of the formerly applied strips.

Head Bandages.—Fronto-occipital Bandage (Fig. 191).—Roller two inches wide, four yards long. Application: Fix the initial extremity of the bandage beneath the inion with the index-finger of the left hand. Carry the roller across the parietal bone of the left side to the forehead, around the forehead, then over the right parietal region to its starting-point. Repeat this, taking care that each turn accurately covers the preceding turn. Complete by fastening under the inion.

Oblique Bandage (Fig. 192).—Roller two inches wide, four yards long. Application: Fix the initial extremity of the bandage by means of one

Fig. 191.—Fronto-occipital Bandage.

Fig. 192.—Oblique Bandage.

or two fronto-occipital turns. From the occiput, pass the roller obliquely over the first parietal eminence to the forehead, make a fronto-occipital turn, ending at the forehead, pass obliquely over the second parietal eminence to the occiput, then make a fronto-occipital turn. Continue these turns in the order named, making each oblique turn over the lower two-thirds of the preceding turn. Complete the bandage by a fronto-occipital turn.

Recurrent Bandage (Fig. 193).—Roller two inches wide, seven yards long. Application : Make one or two fronto-occipital turns to secure the initial extremity of the bandage. Beginning at the central point of the forehead, make a reverse and carry the roller directly backward in the median line over the vertex to just below the inion; at this place fold the bandage on itself and

carry it forward to the left of the first turn, so that it overlaps it by two-thirds. Repeat these recurrent turns between the occiput and the forehead until the

Fig. 193.—Recurrent Bandage, or Capeline of the Head.

Fig. 194.—V-bandage of Head and Chin.

Fig. 195.—Barton's Bandage.

whole of the left half of the skullcap is covered. Then secure these by a fronto-occipital turn.

Forehead and Chin (Fig. 194).—Roller two inches wide, seven yards long.

Application: Fix the initial extremity of the bandage by one or two fronto-occipital turns. From below the inion pass below the right ear around the side of the jaw to the chin, across the anterior surface of the chin, along the left side of the jaw, and below the left ear to below the inion; then make a fronto-occipital turn. Alternate these fronto-occipital turns with the occipitomental turns. Instead of passing from the occiput to the chin, the second turn may pass from the occiput to the upper lip, if so indicated. This bandage is known as the **forehead and upper lip bandage.** If the second turn passes around the neck, it is known as the **forehead and neck bandage.** Or, the second turn may cross any part of the nose, and the bandage is then called **forehead and nose bandage.**

Occipitofacial.—Roller two inches wide, four yards long. Application: This bandage consists of two turns which are identical with the first

Fig. 196.—Modified Barton's Bandage for Lower Jaw.

two turns of G i b s o n ' s bandage (*vide infra*). The intersections are fastened by means of safety-pins.

Barton's Bandage (Fig. 195).—Roller two inches wide, seven yards long. Application: With the index-finger of the left hand fix the initial extremity of the bandage to the vertex of the head in the middle line. Pass down over the left parietal bone to the starting-point. This forms turn number 1. To form turn number 2, continue from the starting-point over the temporal bone of the left side, down the side of the left cheek in front of the left ear, under the chin, up the side of the right cheek in front of the right ear, and over the right temporal bone to the starting-point. To form turn number 3, continue from the starting-point over the left parietal bone to below the inion, below the right ear around the right side of the inferior maxilla to the front of the chin, passing around the anterior aspect of the chin to the left aspect of the inferior maxilla,

over this and below the left ear to just below the inion. These three turns repeated a number of times in the order given constitute B a r t o n ' s bandage proper. In the **modified Barton's bandage** (Fig. 196), after the third turn, there is added a fronto-occipital turn. The points of intersection of the various turns are secured by means of safety-pins.

Gibson's Bandage (Fig. 197).—Roller 2 inches wide, 7 yards long. Application: Fix the initial extremity in front of the ear, carry the roller beneath the jaw, up on the other side and over the fronto-parietal region to the place of beginning. After making three such vertical turns a reverse is made a little above the ear and three horizontal turns are made surrounding the head. A reverse is then made in front at the root of the nose and the bandage carried backward over the head to the nucha, where it is again reversed and three or more turns are made around the front of the chin.

Fig. 197.—Gibson's Bandage.
Safety-pins should be placed on all the intersections to prevent the bandage from slipping.

The points of reverse and intersection of the bandage are secured with safety-pins. One or two final vertical turns add to the neatness of the chin portion of the bandage.

Oblique Bandage of Jaw (Fig. 198).—Roller two inches wide, seven yards long. Application: Fix the initial extremity by means of one or more fronto-occipital turns. If it is intended to cover in the left side of the jaw, the bandage is passed from right to left; if the right side, from left to right. From the occiput, pass below the ear, under the chin, and bring the bandage up over the opposite angle of the jaw, thence carry it over the side of the face just posterior to the external angular process of the frontal bone and in front of the ear of the same side to the vertex. Carry the bandage across the vertex behind the ear of the opposite side to the point at which it first passed under the chin, continue around under the chin as before, this time, however, placing the turn so

as to overlap the posterior two-thirds of the previous turn. Continue these turns, each turn overlapping the posterior two-thirds of the previous turn, until the

Fig. 198.—Oblique Bandage of Angle of the Jaw.

Fig. 199.—Combined Head, Neck, and Figure-of-8 of the Axilla.

space between the external angular process and the ear is completely covered in; the oblique turns may include the ear, if so indicated. Then carry to above the

opposite ear, reverse, make two or three fronto-occipital turns, and fasten. The oblique turn may be applied on both sides, one alternating with the other. This bandage may be combined with the forehead and neck bandage and with the figure-of-8 of the neck and axilla (*vide infra*). Combined thus and taking in with its oblique turns both sides of the head and omitting the ear, it makes the best bandage known for securing dressings after operation on the neck (Fig. 199).

Single Eye Bandage (Fig. 200).—Roller two inches wide, four yards long. Application: Fix the initial extremity by one or two fronto-occipital turns. If it is desired to cover in the left eye, the turns should pass from right to left; if the right eye, *vice versa*. From the occiput, the roller passes below the lobe of the ear to the cheek, upward over the cheek to the glabella, thence obliquely over the frontal and parietal region of the opposite side to the occiput.

Fig. 200.—Single Eye Bandage.

Fig. 201.—Double Eye Bandage.

This forms turn number 1. A fronto-occipital turn is now made. Turn number 2 is identical with turn number 1, except that it ascends and overlaps the latter by one-third its width. It will be found more comfortable for the patient if the second turn and subsequent turns cover in the ear instead of passing below it, as in the case of the first turn. These turns are repeated, alternating with the fronto-occipital turns until the eye is entirely covered in. A few fronto-occipital turns complete the bandage. The ear is protected from pressure by cotton.

Double Eye Bandage (Fig. 201).—Roller two inches wide, six yards long. Application: The initial extremity is fixed by one or more fronto-occipital turns. Then from the occiput the roller passes under the lobe of the first ear to the cheek, upward upon the cheek to the glabella, covering in the first eye, and thence obliquely across the opposite frontal and parietal region to the occiput. A fronto-occipital turn is now made. From the occiput, the

roller now travels up over the parietal and frontal regions to the glabella, then over the second eye obliquely down the cheek beneath the lobe of the

Fig. 202.—Bandage for Supporting Tampons in Anterior Nares.

Fig. 203.—Figure-of-8 Bandage of the Neck and Axilla.

ear to the occiput. A fronto-occipital turn is now made. The turn covering in the first eye is now repeated, two-thirds of the previous turn are covered in,

then a fronto-occipital turn is taken and the turn covering in the second eye is repeated, and so on, each eye turn ascending by two-thirds of the width of the preceding turn and alternating with a fronto-occipital turn. These are continued until the eyes are completely covered in.

Bandages of the Trunk and Extremities.—Figure-of-8 of the Neck and Axilla (Fig. 203).—Roller two inches wide, four yards long. Application: Fix the initial extremity of the bandage by one or two circular turns around the neck, not too tightly applied. According to the axilla to be included, pass the roller obliquely across the corresponding shoulder under the axilla, and back again obliquely over the same shoulder, crossing the first oblique

Fig. 204.—Spiral Bandage of the Chest. First Method.

Fig. 205.—Spiral Bandage of the Chest. Second Method.

turn. Now take a circular turn around the neck. Alternate the circular neck-turns with the turns passing under the axilla and crossing over the shoulder. Each succeeding turn overlaps the preceding one by two-thirds its width. A circular turn around the neck completes the bandage.

Spiral Bandage of the Chest (Fig. 204).—Roller three inches wide, eight yards long. Application: The initial extremity of the roller is fixed by means of one or two circular turns around the chest at the level of the xiphoid cartilage. The roller then gradually ascends the chest by means of spiral turns, each turn covering in two-thirds of the preceding one, until the level of the axillary fold is reached. Here one or two circular turns complete the bandage.

Another way of completing the bandage is to make one circular turn at the level of the axillary folds, pass under the axilla to the posterior aspect of the chest, thence obliquely to the opposite shoulder, over this to the anterior aspect of the chest wall and diagonally down over the turns of the bandage to the xiphoid cartilage, where the bandage ends. This last oblique strip is secured by pins to each spiral turn of the bandage (Fig. 205). Or, the spiral turns may be supported by shoulder-straps pinned in front and behind (Fig. 206).

Anterior Figure-of-8 of the Chest (Fig. 207).—Roller three inches wide, eight yards long. Application: Two or more circular turns are first made around the chest at the level of the axillary folds. From a point commencing

Fig. 206.—Spiral Bandage of the Chest. Third Method.

at the center of the sternum, the roller is carried over one shoulder to its posterior aspect, through the axilla of the same side to the anterior aspect of the chest, diagonally across the chest to the other shoulder, then over the other shoulder to its posterior aspect, through the axilla to the anterior aspect of the chest, and diagonally across it to the starting-point, thus forming a cross over the sternum. These turns repeated a number of times complete the bandage. Or, the circular turns may alternate with the figure-of-8 turns. The turns may be placed so that each will exactly cover in the preceding one or overlap it by a portion of its width. Finally, the bandage is secured by a pin through the intersection of the turns over the sternum.

Fig. 207.—Oblique Bandage of the Head and Anterior Figure-of-8 of the Chest.

Fig. 208.—Posterior Figure-of-8 Bandage of the Chest.

Posterior Figure-of-8 of the Chest (Fig. 208).—Roller three inches wide, eight yards long. Application: The initial extremity of the bandage is fixed between the scapulas at the level of the axilla, and the roller carried over one shoulder to its anterior aspect, through the axilla of the same side to its posterior aspect, and thence to the starting-point. The roller is then carried in a similar manner around the other shoulder, and these turns are alternated first around one shoulder and then around the other until the roller is finished. The bandage is pinned at the point of intersection between the scapulas.

Breast Bandage (Fig. 209).—Single roller three inches wide, eight yards long. Application: Starting from the scapula of the affected side, carry the roller over the shoulder of the opposite side to the anterior chest wall,

Fig. 209.—Bandage Sling for the Breast.

Fig. 210.—Double Breast Bandage.

and thence under the affected breast and obliquely along the lateral and posterior chest wall to its starting-point. Repeat this turn in order to secure the initial extremity. This is turn number 1. Turn number 2 is an oblique one, starting from the initial extremity over the scapula of the affected side and going completely around the body just under the affected breast. These two turns are alternated, each covering in its corresponding preceding turn by two-thirds its width, thus gradually ascending and covering the breast completely. To support both breasts the bandage is repeated on the opposite side (Fig. 210).

Ascending Spica of the Shoulder (Fig. 211).—Roller three inches wide, eight yards long. Application: Fix the initial extremity of the roller by means of one or two circular turns around the arm of the affected side at the level of the axillary fold, or at a short distance below it. Carry the bandage

directly across the anterior aspect of the chest to the axilla of the opposite side, under the axilla to the posterior aspect of the chest, and across this to the starting-point. Make a circular turn around the arm at the starting-point and then a second turn around the chest, similar to the first, but ascending and covering in two-thirds of the previous turn, except at the opposite axilla where the turns exactly overlap each other. The chest turns are alternated with the circular turns around the arm, each chest turn ascending and covering the preceding turn by one-third of its width. In this manner the shoulder is ascended by spica turns until it is completely covered. The bandage is completed by a circular turn around the arm and there fastened.

Descending Spica of the Shoulder.—Roller two and a half inches wide, seven yards long. Application: Fix the initial extremity of the bandage by means of one or two circular turns around the arm at the level of the

Fig. 211.—Ascending Shoulder Spica.

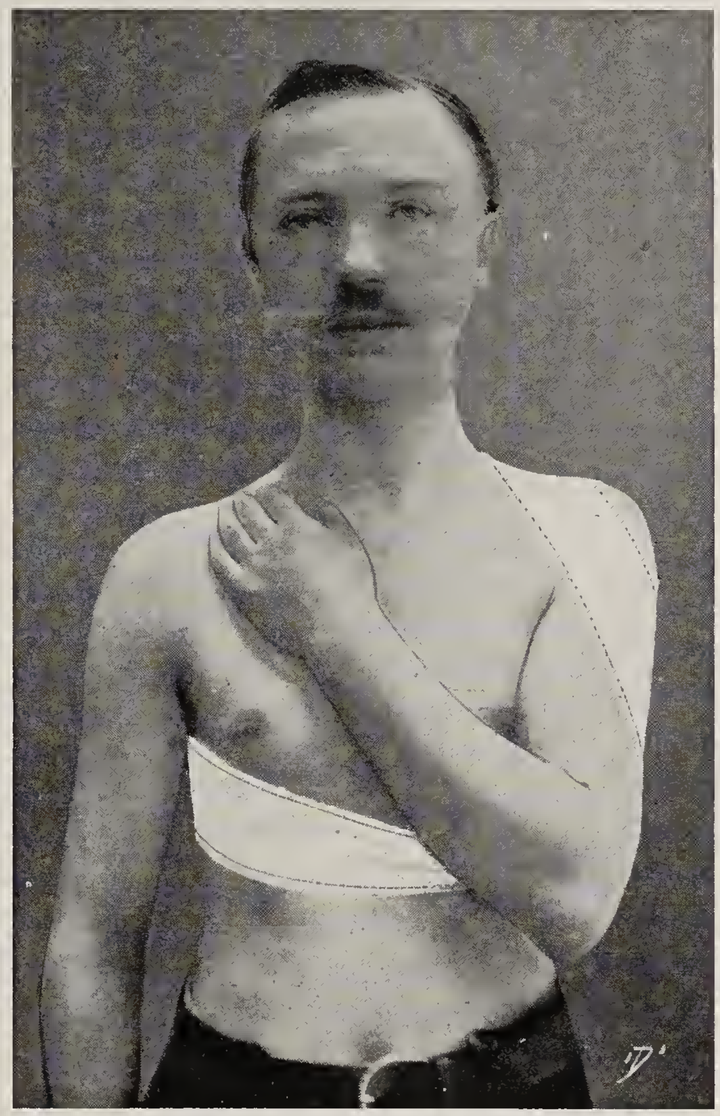


Fig. 212.—Velpeau's Bandage. First Turn.

axillary fold or at a short distance below it. Carry the roller over the shoulder and the anterior surface of the chest as high up as it can be made to go, thence around the axilla of the opposite side, around the posterior aspect of the chest and over the shoulder to the starting-point. Here a circular turn is taken. These turns are alternated, each chest turn descending by one-third the width of the preceding turn until the shoulder is completely covered. The bandage is finally completed by a circular turn around the arm.

Velpeau's Bandage (Figs. 212, 213, and 214).—Two rollers, three inches wide, eight yards long. Application: The arm of the affected side is drawn across the chest, the palmar surface of the fingers resting on the point

of the sound shoulder, with a layer of cotton between. The initial extremity of the roller is placed over the scapula of the unaffected side, and the roller carried over the point of the opposite shoulder, thence down across the outer and then the posterior surface of the arm of the same side and under the elbow to the anterior chest wall to the axilla of the unaffected side and thence to the starting-point, the first turn being thus completed. This turn is repeated in order firmly to fix the initial extremity of the roller. After this second turn is completed, the roller is carried directly around the body, passing over the elbow of the affected side near its point, thence to the axilla of the sound side, and thence to the starting-point over the scapula of the sound side. These turns are alternated, each succeeding turn overlapping the previous one by two-thirds

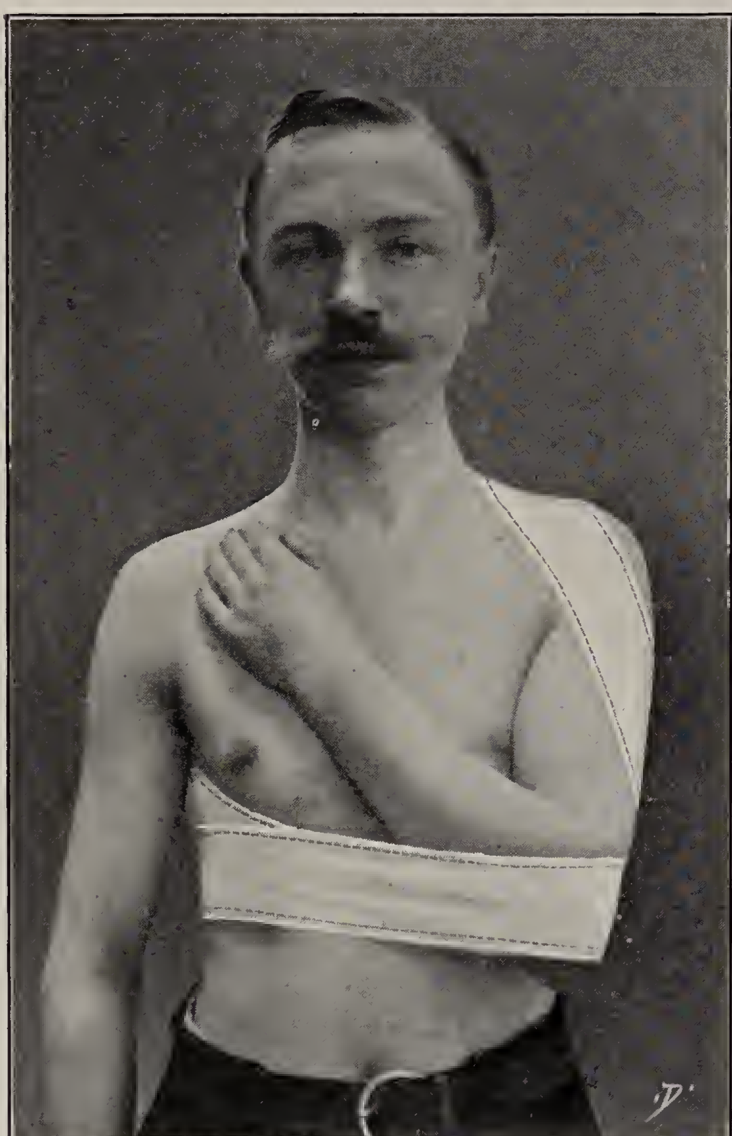


Fig. 213.—Velpeau's Bandage. Second Turn.

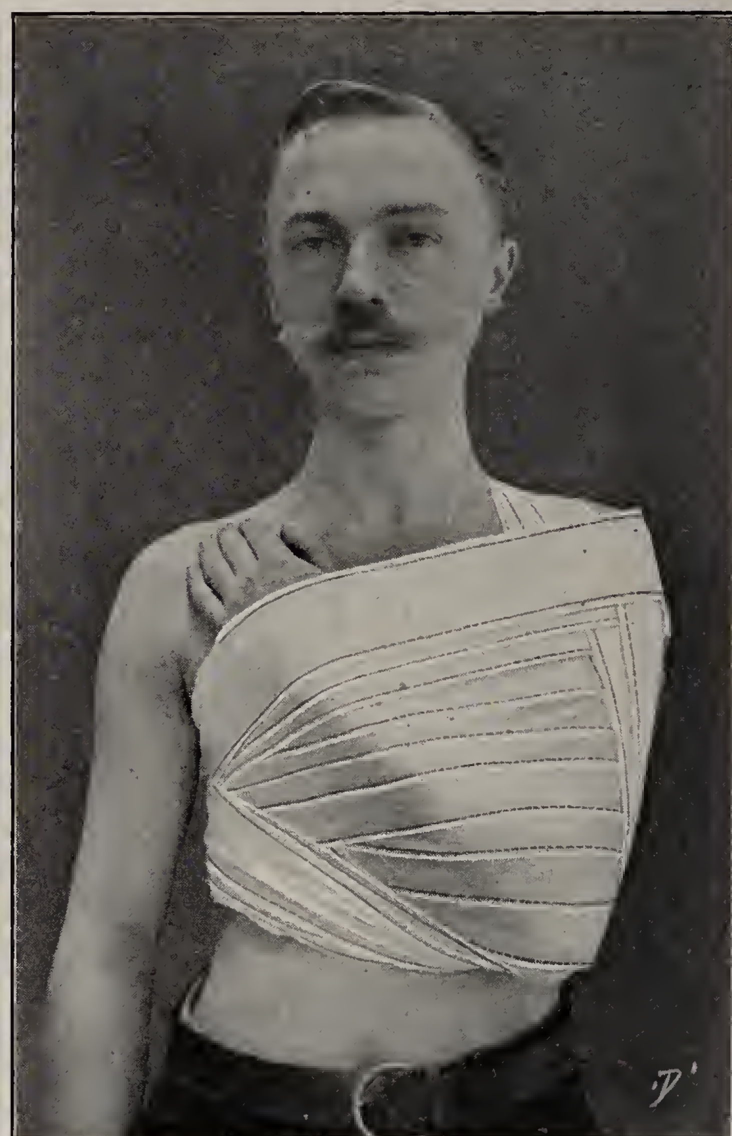


Fig. 214.—Velpeau's Bandage Completed.

its width, the shoulder turns gradually approaching the base of the neck, and the turns crossing the elbow gradually ascending to the shoulder, until the last turn passes across the wrist and is secured behind.

Figure-of-8 of the Elbow (Fig. 216).—Roller two inches wide, four yards long. Application: Place the elbow in the position in which it is to remain and pass two circular turns around the flexure and tip of the olecranon. Circular turns are now made alternately above and below the joint until the latter is completely covered, each turn covering in two-thirds of the preceding one. Or, fix the initial extremity of the bandage by one or more circular turns a few inches above the joint. Return obliquely to the starting-point and

make a circular turn. Alternately make a circular turn above the joint, gradually approaching the tip of the olecranon from both directions; finally

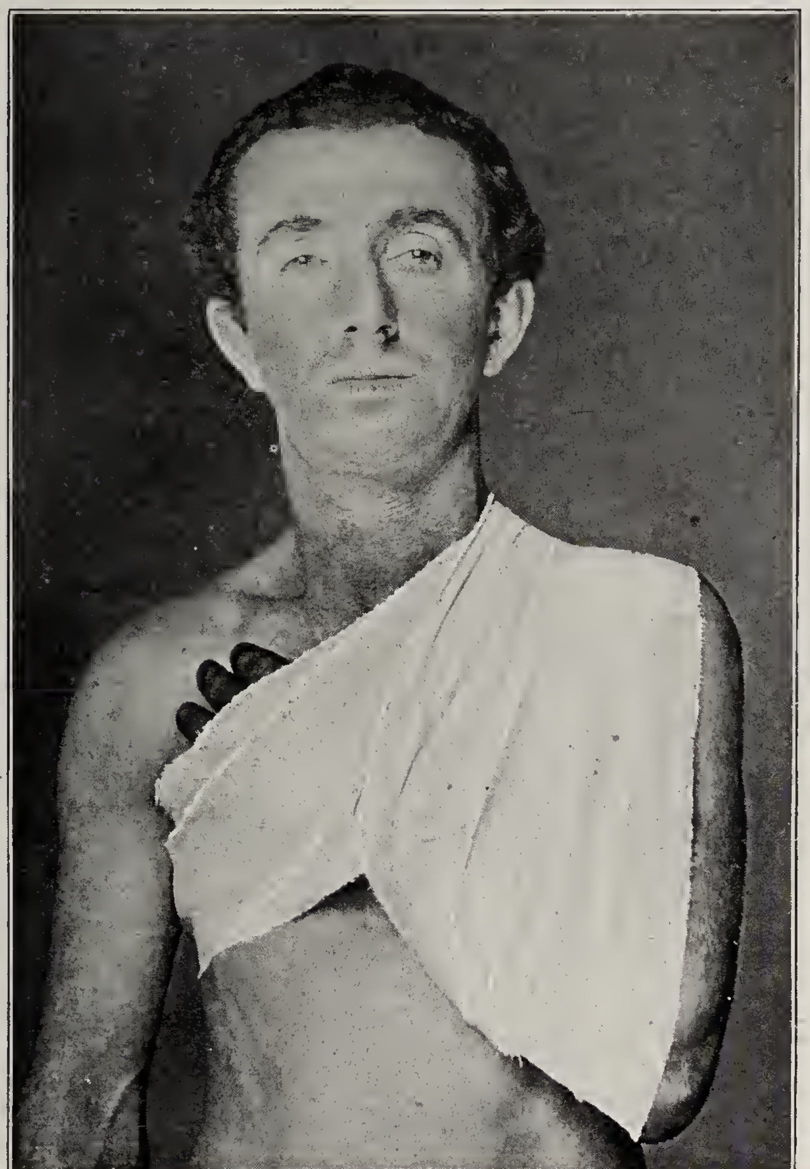


Fig. 215.—Arm and Hand Sling.

Fig. 216.—Figure-of-8 of the Elbow.

complete by a circular turn directly around the flexure and covering in the olecranon.

Figure-of-8 of the Hand and Wrist (Fig. 217).—Roller, one, two, or three and a half inches wide, two yards long. Application: Fix the initial end of the roller by one or two circular turns at the wrist. Carry it obliquely across the dorsum to the base of the index-finger or little finger, make one circular turn, followed by one half turn around the hand at the metacarpophalangeal articulation, and return to the wrist. After completing a circular turn at the wrist, again carry it obliquely to the base of the index or little finger, and proceed as before. The turns are continued, each overlapping the preceding one by two-thirds its width, until the dorsum of the hand is completely covered. A circular turn at the wrist completes the bandage.

Fig. 217.—Figure-of-8 of the Hand and Wrist.

Figure-of-8 of the Hand and Wrist (Palmar Application).—This is applied in the same manner as the preceding, except that the oblique turns cross the palm instead of the dorsum of the hand.

Fig. 218.—Bandage for Wrist, Forearm, and Elbow.

Reversed Spiral of Upper Extremity (Fig. 218).—Roller two and a half inches wide, seven yards long. Application: Fix the initial extremity of the bandage by means of one or two circular turns around the wrist; cross the back of the hand obliquely to the level of the last phalangeal joints, where a circular turn is made; then by means of spiral or reversed spiral turns ascend the hand to the metacarpophalangeal joint of the thumb; pass obliquely to the wrist and take a circular turn at this point; then back obliquely to take a circular turn around the body of the hand. Make three or more of these figures-of-8 and finish by a circular turn at the wrist. Ascend the forearm by means of

Fig. 219.—Spiral of the Finger.

spiral and reversed spiral turns until the elbow is reached. If it is desired to keep the arm flexed, cover in the elbow by a series of figure-of-8 turns while in flexion; if, however, the arm is to be kept extended, continue the spiral and reversed turns over the elbow and up the arm. The bandage is completed by one or two circular turns at the level of the axillary fold. Care should be taken here, as elsewhere, not to allow the reverses to press over bony prominences, as, for instance, the ridge of the ulna; also to keep the reverses in line.

Spiral of the Finger (Figs. 219 and 220).—Roller three-quarters of an inch wide, three yards long. Application: The initial extremity of the roller is secured by two or three turns around the middle phalangeal joint. The bandage is carried in a spiral manner to the base of the finger, each turn covering one-half of the preceding turn. A circular turn is made at the base of the finger, and the bandage carried by means of spiral turns to its starting-point at the middle phalangeal joint. From the posterior surface of the joint a recurrent turn is now passed directly over the tip of the finger to the anterior surface of the joint. The fingers of the operator's left hand hold the extremities of this turn taut and in position while a second turn is passed back over the inner half of the finger-tip to the starting-point of the first. This is also held in place while a third and final turn is passed over the outer half of the finger-tip to the anterior surface of the joint. A circular turn secures the ends of the three loops, the bandage being then carried to the distal extremity of the finger by means of spiral turns. At the extremity another circular turn is taken, which secures the parts of the loops extending to the right and left side of the finger-tip. Finally, by means of spiral turns the base of the finger is reached and the bandage fastened either by splitting longitudinally for a distance of six or eight inches, knotting the bandage to prevent further splitting, and tying the ends directly around the base of the finger; or by splitting for a distance of ten or twelve inches, tying at the base of the finger and carrying the superfluous ends around the wrist once or twice in opposite directions, and finally tying. This last effectually prevents the loosening and falling off of the bandage.

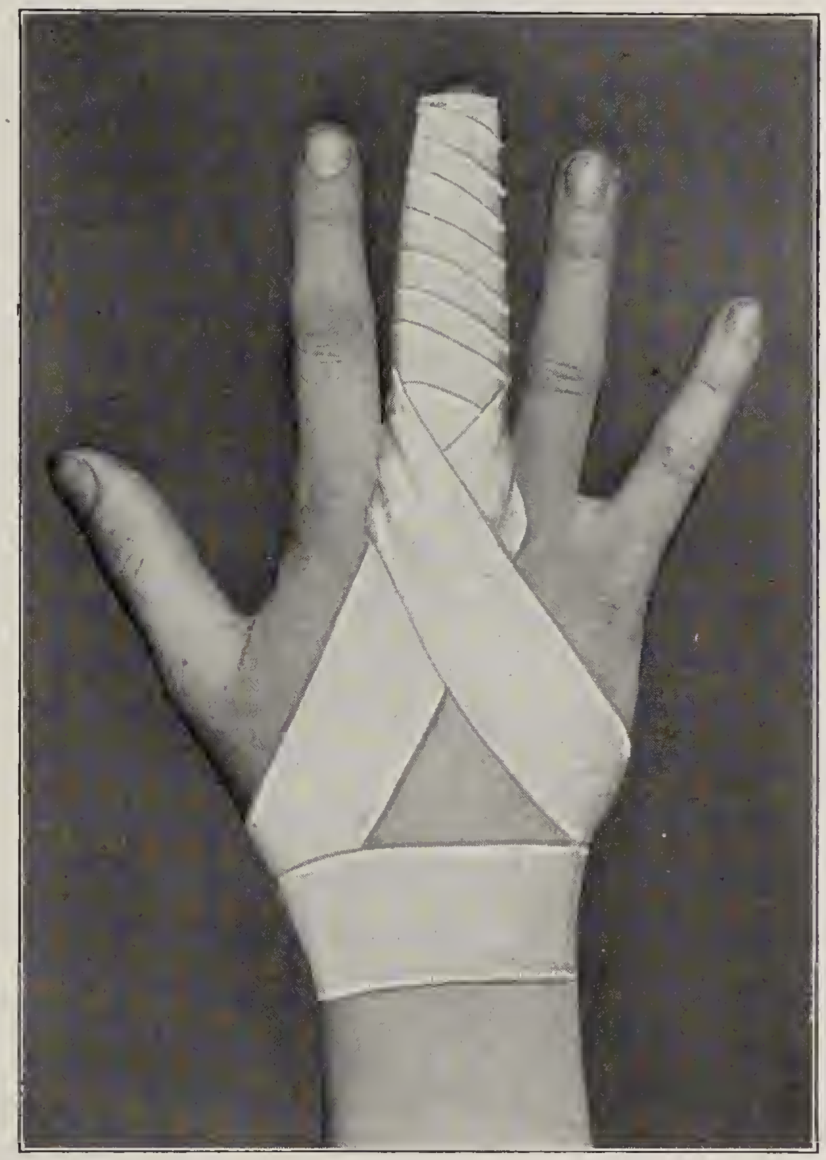


Fig. 220.—Spiral Bandage of Finger. Second Method.

The reversed spiral of the finger is applied in the same manner as the spiral, with the exception that reversed spiral turns take the place of spiral turns.

Spica of Thumb (Fig. 221).—Roller one inch wide, three yards long. Application: Fix the initial extremity at the wrist by one or two circular turns. Carry the roller over the dorsal aspect to the tip of the thumb and there make a circular turn; then return to the wrist and make a circular turn around the wrist. The roller is again carried across the dorsal aspect of the thumb and a second circular turn is made around the thumb, this last overlapping the first in the direction of the base of the thumb by two-thirds of its width. This procedure is continued until the thumb is covered. A turn around the wrist completes the bandage, which is then fastened. Spiral turns may be used around the thumb in place of circular ones. A few recurrent turns may be first placed over the tip, if it is desirable to inclose it in the bandage.

Fig. 221.—Spica of the Thumb.

Any of the above described spiral or reversed spiral bandages of the finger may be applied to the thumb.

Demi-gauntlet (Dorsal) (Fig. 222).—Roller one inch wide, four yards long. Application: Fix the initial extremity at the wrist by one or two circular turns. Carry the roller obliquely across the back of the hand to the base of the thumb; here make a circular turn and return to the wrist. Make a circular turn at the wrist and then carry the roller obliquely across the back of the hand and the base of the index-finger, there making a circular turn, and return to the wrist. So continue until the base of each finger has received in due order the same circular turn. Complete a few figure-of-8 turns of the hand and wrist.

Fig. 222.—The Demi-gauntlet Bandage (Dorsal).

Demi-gauntlet (Palmar).—Same as the preceding, except that the oblique

turns from the wrist to the base of the finger are passed over the palmar instead of the dorsal surface.

FIG. 223.—THE GAUNTLET.

The Gauntlet (Fig. 223).—Roller one inch wide, three yards long. Application: Fix the initial extremity by means of one or two circular turns at the wrist. Carry the roller by an oblique turn to the tip of the thumb and cover the latter by spiral or reversed spiral turns. The bandage is then carried back to the wrist and a circular turn made around it, then carried to the index-finger, which is bandaged in the same manner as the thumb. In like manner the remaining fingers are covered, the bandage being completed by a few circular turns at the wrist and there fastened, or a few additional figure-of-8 turns may be passed around the hand and wrist for further security.

Ascending Single Spica of the Groin (Fig. 224).—Roller three inches wide, eight yards long. Application: Fix the initial extremity of the bandage by means of one or two circular turns just above the level of the iliac crests. If the right groin is the one to be covered in, the roller should run anteriorly from left to right, and in the reverse direction in the case of the left groin. Carry the roller from the summit of the iliac crest opposite the groin to be bandaged, obliquely across the anterior surface of the abdomen to the outer side of the thigh of the affected side at the junction of its middle and upper third. A circular turn and a half is now made around the thigh at this point, the roller finally emerging on the inner side of the thigh, whence it is carried obliquely across the front of the latter, crossing the first oblique part as low down as possible in the middle line of the thigh, thence over the groin to

FIG. 224.—ASCENDING SINGLE SPICA OF THE GROIN.

the lateral aspect of the ilium of the same side, then around posteriorly in a slightly oblique direction to the iliac crest of the side from which it started.

Fig. 225.—Descending Single Spica of the Groin.

A circular turn is now made around the body just above the iliac crest as in the first turn which secured the initial extremity. The spica turns are alternated with the circular turns around the body, the circular turns around the thigh each ascending one-third of the width of the bandage and the spica turns also ascending one-third of their width. In this manner the upper third of the thigh and all of the groin is completely covered in. The circular turn around the body, or that around the thigh, or both, are sometimes omitted. The spica turns should cross each other exactly in the middle line of the thigh and groin. If, in bandaging the right thigh, the bandage is started around the body from right to left, instead of from left to right, the roller will be carried obliquely across the groin from the lateral surface of the iliac crest of the affected side to the internal aspect of the thigh at the junction of its middle and upper third. Here a circular turn and a half is made. The roller, emerging on the outer side of the thigh, is carried across the anterior surface of the thigh, crossing the first oblique part in the middle line of the thigh as low down as possible, and is carried obliquely across the anterior surface of the abdomen to the iliac crest of the opposite side, and thence circularly around the body to its starting-point. If, in bandaging the left groin, the roller is started from left to right, the above description also holds good for that side.

Fig. 226.—Ascending Spica of Both Groins.

Descending Single Spica of Groin (Fig. 225).—Roller three inches wide, eight yards long. Application: The descending spica of the groin is

applied in the same manner as the ascending spica, and consequently the same description and rules hold good for both, with the exception that, whereas in the case of the ascending spica the first spica turn is placed at the junction of the middle and upper third of the thigh, and the subsequent spica turns ascend from that point one-third of their width, in the case of the descending spica the first spica turn is placed as high as possible and the subsequent spica turns descend one-third of their width until the junction of the middle and upper third of the thigh is reached.

Ascending Spica of Both Groins (Fig. 226).—Roller three inches wide, ten yards long. Application: Fix the initial extremity of the bandage by means of one or two circular turns around the body just above the level of the iliac crests. The roller runs from left to right or from right to left according to the thigh which is to receive the first spica turn. From the iliac crest of one side, the roller is carried obliquely across the anterior surface of the abdomen and groin to the external surface of the opposite thigh at the junction of its middle and upper third. Here make a circular turn and a half, emerge from the inner side of the thigh obliquely across the first oblique part in the middle line as low down as possible on the thigh, ascend obliquely to the lateral surface of the ilium of the same side, thence obliquely around the body posteriorly to the opposite iliac crest. Now carry a circular turn around the body ending above the iliac crest opposite the groin yet to be encircled. Proceed obliquely across the back to the lateral aspect of the iliac bone of the opposite side and thence obliquely over the anterior surface of the groin of that side to the interior surface of the thigh at the junction of its middle and upper third. Here make a circular turn and a half, and, emerging on the external surface of the thigh, ascend obliquely over the anterior surface of the groin, crossing the first part of this spica turn in the middle line of the thigh. Carry the roller on obliquely over the anterior surface of the abdomen to the opposite iliac crest. Here make a circular turn around the body. These turns are repeated in order, first a circular one around the body, then a spica turn around one groin which

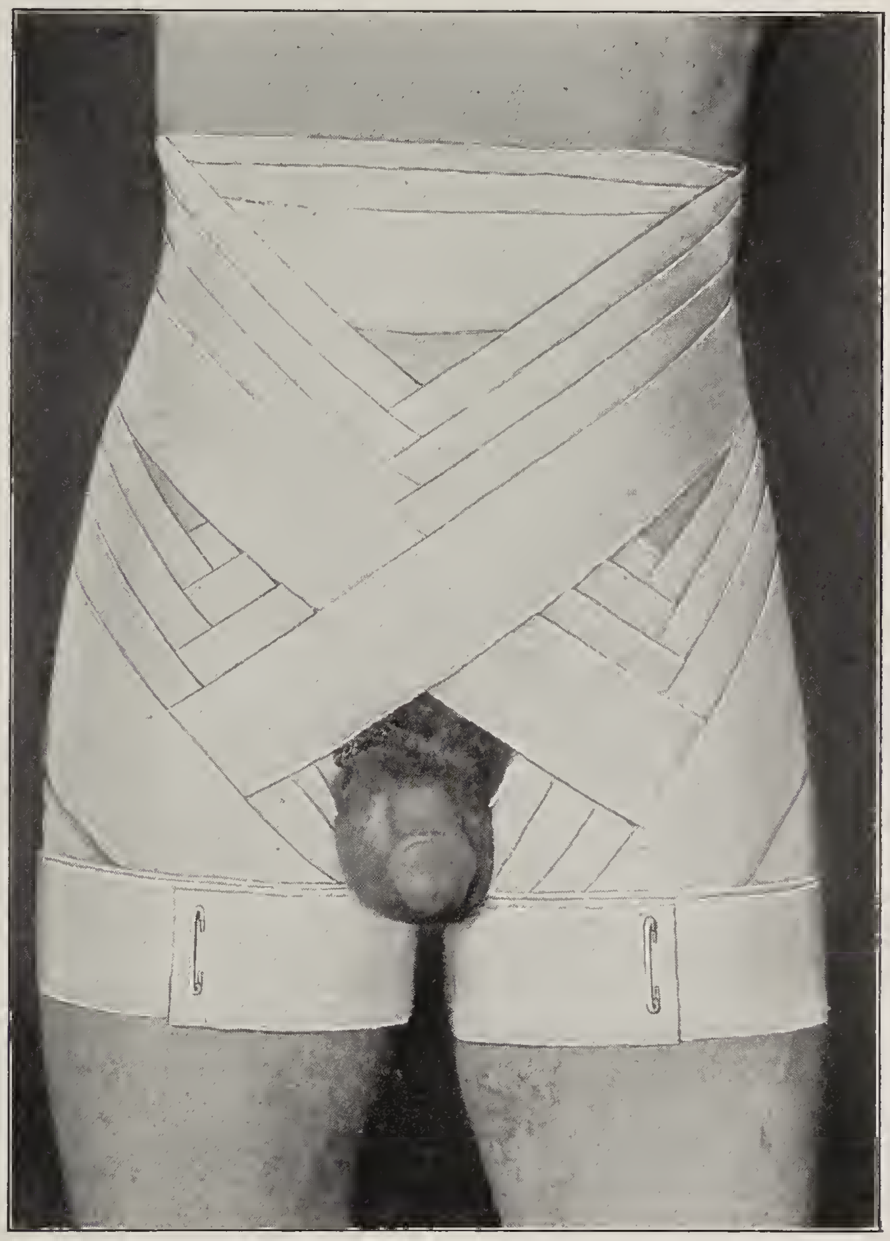


Fig. 227.—Double Descending Spica of Groin.

emerges from the outer side of the thigh after surrounding it by a circular turn, then a circular turn around the body until both groins and the upper thirds of both thighs are completely covered in, the circular turns around the thigh ascending one-third of their width, and the spica turns of both groins ascending likewise one-third of their width. Either the circular turns around the body or the circular turns around the thighs or both may be omitted. The bandage is fastened at its intersections at the back over the anterior surface of the abdomen and also at the spica intersections on the thigh and groin.

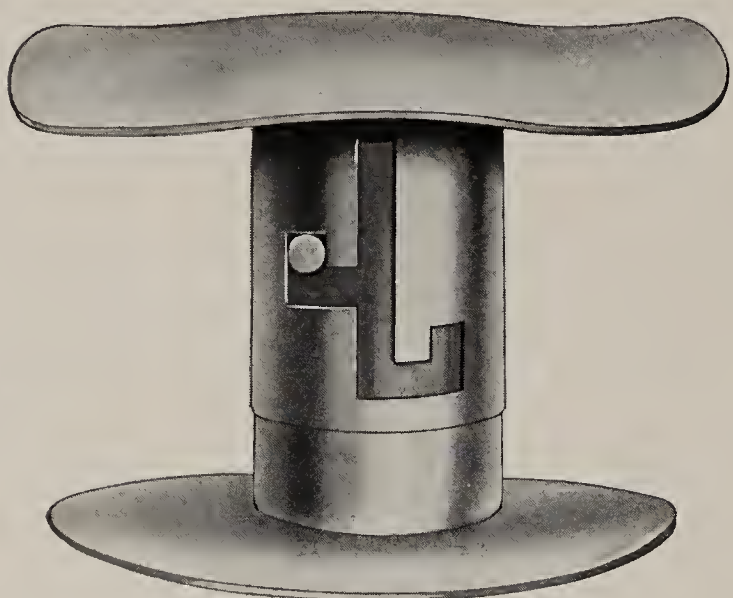


Fig. 228.—Volkmann's Block.

Descending Spica of Both Groins (Fig. 227).—Roller three inches wide, ten yards long. Application: The descending spica of both groins is applied in the same manner as the ascending spica, with the exception that the oblique turns in the descending spica begin to cross high up and descend to the junction of the middle and upper third of the thigh by one-third of the width of the roller. Otherwise the bandage is applied in the same manner.

In applying the spicas of the groin the patient should be raised from the table and supported on a Volkmann's block (Fig. 228). In the absence of the latter, an inverted basin answers the purpose.

Figure-of-8 of Knee (Fig. 229).—Roller three inches wide, six yards long. Application: Fix the initial extremity of the bandage by means of one or more circular turns a short distance below the knee-joint. Carry the roller obliquely across the popliteal space, the first oblique turn crossing the middle line to the inner surface of the thigh. Here make a circular turn, followed by a second which overlaps the first by two-thirds of its width and approaches the knee-joint by one-third of its width. Again cross the popliteal space to the circular turns below, and here make another circular turn which ascends toward the knee-joint by one-third of its width. Continue to make circular turns above and below the knee, the upper ones gradually ascending until the knee is entirely and securely covered.

Fig. 229.—Figure-of-8 of the Knee.

Spiral of the Foot.—Roller two inches wide, five yards long. Applica-

tion: Fix the initial extremity above the internal malleolus with the finger-tips of the left hand. Carry the roller around the ankle anteriorly to the point of commencement, crossing the initial extremity and then fixing it. The roller now crosses the instep to the base of the toes. Here a circular turn is made, and, succeeding this, spiral turns ascend the foot and instep as far as the conformity of the parts permit. The roller is then carried to the ankle; a few circular turns are here made, and the terminal extremity fastened.

FIG. 230.—FIGURE-OF-8 OF THE FOOT AND ANKLE.

Figure-of-8 of Foot and Ankle (Fig. 230).—Roller two inches wide, five yards long. Application: Fix the initial extremity of the bandage as in applying the spiral of the foot. Carry the roller obliquely across the instep to the base of the toes. Here make a circular turn. Return to the outer malleolus and make a circular turn around the ankle. Continue these turns, one around the ankle, then one around the foot, the ankle turns gradually descending until the foot, instep, and ankle are covered. Then complete by a circular turn around the ankle, and fasten.

Reversed Spiral of the Foot.—Roller two inches wide, five yards long. Application: Same as the spiral bandage except that the spiral turns of the foot and instep are replaced by reversed spiral turns.

FIG. 231.—SPICA OF THE FOOT.

Spica of the Foot (Fig. 231).—Roller two inches wide, five yards long. Application: Fix the initial extremity as in applying the other foot bandages. Carry the roller obliquely across the instep to the lateral aspect of the foot, along the lateral aspect to the posterior surface of the heel low down, thence along the lateral aspect of the foot obliquely across the instep, crossing the corresponding oblique turn to the other side of the foot in the median line. This completes the first spica turn. Repeat these spica turns, ascending by one-third the width of the bandage each time, until the foot and ankle are covered in. Then complete by circular, spiral, or spiral reversed turns around the ankle. A few spiral or reversed spiral turns applied around the instep before beginning the spica, and similar turns about the ankle on completion of the spica, add to the neatness of the bandage. The spica points should always be in the median line.

Recurrent of Foot.—This is simply one of the usual bandages of the foot among whose turns are included recurrent turns to cover in the toes.

Serpentine of the Foot (Fig. 232).—Roller two and a half inches wide, seven yards long. Application: The initial extremity of the bandage is fixed in the same manner as in the case of other bandages of the foot. The roller is carried obliquely across the instep to the base of the toes, where a circular turn and a half is made, bringing the roller to the middle line anteriorly. Now carry the roller obliquely to the outer edge of the sole under the hollow arch of the foot to the interior lateral aspect of the heel low down, thence obliquely up over the posterior aspect of the heel to the external malleolus. Here make a circular turn around the ankle. This is turn number one. Then obliquely across the instep to the base of the toes, the roller naturally coming to the internal aspect of the base of the toes, whereas in turn number one it came to the external aspect. Take a circular turn and a half around the base of the toes as in turn number one. Thence obliquely over the instep to the internal edge of the sole of the foot, on around beneath the hollow arch of the foot obliquely to the external lateral aspect of the heel low down, thence obliquely up over the posterior aspect of the heel to the internal malleolus. Now make a circular turn around the ankle. This is turn number two. Turn number three is simply a circular turn around the instep and point of the heel, its edges being held and covered in by a repetition of turns one and two, so that the heel is completely covered. Turns one, two, and three are repeated until the parts are covered. A few spiral turns above the malleoli complete the bandage.

Fig. 232.—Serpentine of the Foot.

Combinations of Spiral, Reversed Spiral, Spica, and Figure-of-8.—Recurrent and serpentine bandages of the foot may be used as indications for them arise in individual cases. It is sometimes necessary in strapping the joint to carry spiral or reversed spiral turns above the ankle. This may also be done to add finish to a bandage.

If it is not necessary to cover in the heel, the circular turns of the heel and instep should be omitted. If the toes are to be covered, recurrent turns may be introduced. This bandage is the best of the foot bandages, as it is easy to apply and stays firmly in place.

Reversed Spiral of Lower Extremity (Fig. 233).—Roller two and one-half inches wide, seven yards long. Application: One of the foot bandages is first applied, except that, instead of ending the bandage at the ankle, the

roller is carried up the leg by means of spiral or reversed spiral turns according to the shape of the limb, until the knee is reached. The bandage may be ended here with a few circular turns, or, with the leg in the extended position, it may be continued on up the thigh to the groin, and either end there, or a spica of the groin may be added for additional security. If it is desirable to leave the patient's knee in a flexed position, a figure-of-8 bandage of the knee may take the place of the spiral or reversed spiral turns covering in that region.

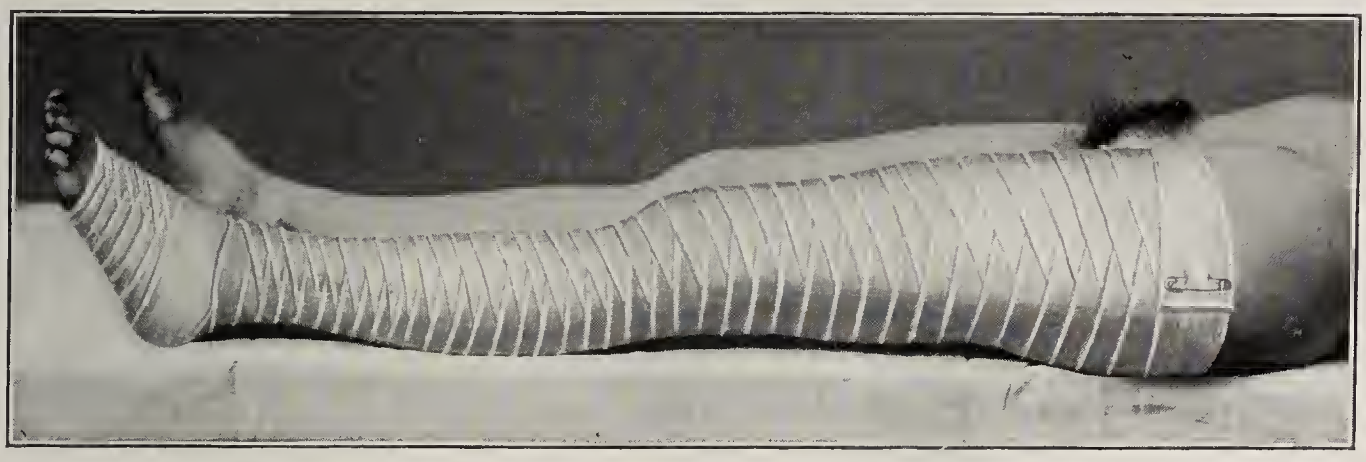


Fig. 233.—Reversed Spiral of Lower Extremity.

Figure-of-8 of Leg (Fig. 234).—Roller two and one-half inches wide, seven yards long. Application: If the leg is fairly well molded, this is the best bandage to use. First apply one of the foot bandages. Then ascend the leg by means of spiral or spiral reversed turns until the lower part of the calf is reached. Here the figure-of-8 turns begin. The bandage is carried obliquely upward and around to the median line posteriorly, whence it is carried obliquely downward and around to the front of the leg, crossing the starting turn as near the median line as is permissible without bringing too much pressure over the long ridge of the tibia. These figure-of-8 turns are repeated, gradually

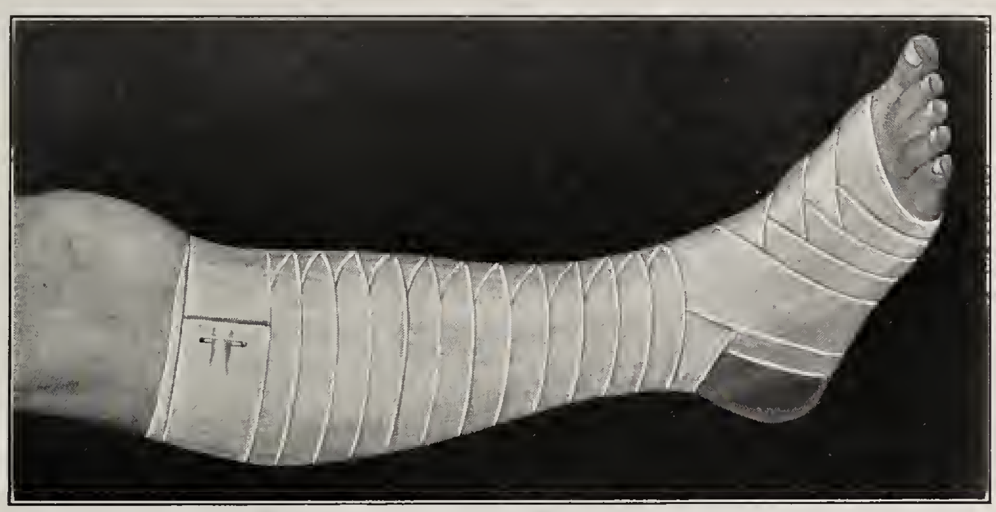


Fig. 234.—Figure-of-8 of Leg.

ascending the leg until the calf is covered. The bandage is completed by one or more circular turns around the leg just below the knee.

Spica of Great Toe (Fig. 235).—Roller one inch wide, five yards long. Application: This is applied in a manner similar to that employed in the spica of the thumb. The initial extremity of the roller is fastened by one or two circular turns around the ankle. The bandage then crosses the instep of the foot obliquely from the internal malleolus to the outer side of

the great toe. A circular turn is taken around the toe as near the tip as possible and the roller carried from the inner side of the toe obliquely across the instep, crossing the first oblique part as near the end of the toe as possible to the internal malleolus. Here a circular turn is made. If desirable, the tip may be covered in by a few recurrent turns. The spica turns are repeated, ascending toward the base of the toe each time one-third the width of the bandage until the toe is completely covered.

Fig. 235.—Spica of Great Toe.

Serpentine of Great Toe.—Roller one inch wide, six yards long. Application: The initial extremity of the bandage is fastened by means of one or two circular turns around the ankle. The roller is then carried obliquely across the instep to the outer edge of the sole, then obliquely under the sole to a point just posterior to the thenar eminence. It is here brought to the inner edge of the foot, thence across the anterior surface of the base of the toe to its tip. Here a circular turn is made and a few recurrent turns may be added. From the tip the roller crosses the anterior surface of the base of the toe to its tip. Here a circular turn is made and a few recurrent turns may be added. From the tip the roller crosses the anterior surface of the base of the toe and thence obliquely across the base of the other toes to the outer side of the foot at a point opposite the hypothenar eminence. It passes the hollow obliquely just behind the thenar eminence to emerge at the inner edge of the foot, thence obliquely across the instep to the exterior malleolus. Here a circular turn around the ankle is made. These serpentine turns are repeated, each overlapping the preceding one to a slight extent until the toe is completely covered.

PART II

REGIONAL SURGERY

SECTION XIV

THE SURGERY OF THE HEAD

THE SCALP

The thinner portions of the cranium, as, for instance, the temporal regions, are covered with a rather thick cushion—the temporal muscle; but with this exception the bones of the skull are practically unprotected. The epicranial structures are stretched across the skull in such a manner that force applied affects soft parts and bone alike. The elasticity of the cranial vault is such, however, that, on account of its peculiar conformation, it may return to its normal shape after quite a severe blow and only a contusion of the soft parts result.

Simple contusions of the scalp are usually of but slight importance and require no treatment; the extravasated blood is, as a rule, rapidly resorbed. The slightest abrasion of the integument, however, should be treated antiseptically because of the readiness with which inflammatory infection takes place in this region.

Hematoma of the scalp results from rupture of one or more vessels of considerable size. The subcutaneous and subaponeurotic varieties are recognized. In the first named variety a fluctuating swelling surrounded by an indurated border is present. Owing to the soft and apparently depressed center, this condition is sometimes mistaken for a fracture of the skull. This mistake may be avoided by noting the fact that the indurated margin is above the level of the surrounding bone, and, in addition, that it pits on pressure. In the second variety, namely, that which occurs beneath the aponeurosis of the occipitofrontalis muscle, the effusion of blood may separate the latter from the bone for a large area, giving rise to bulging at the supraorbital ridges and in the occipital region. In the **treatment** of a large hematoma it may become necessary to resort to incision and evacuation of the clots and fluid blood, with subsequent drainage.

Wounds of the scalp gape considerably, provided they penetrate to the bone and are transverse; otherwise they do not. This is due to the peculiar anatomic structure of the connective tissue between the scalp and the pericranium, the bony elastic fibers of which permit the retraction of the edges in both directions by the action of the occipitofrontalis when the entire

thickness of the scalp is traversed by the wound. Sharp pointed instruments easily penetrate to the bone, but rarely pass through it, unless directed with great force.

The treatment of incised wounds of the scalp requires on the part of the surgeon the arrest of hemorrhage as his first care. The vascularity of the parts is such that considerable blood may be lost before spontaneous arrest takes place. The rigid fibers of the aponeurotic connective tissue in the scalp, like the walls of the bony canals, prevent retraction of the divided arteries and narrowing of their lumina. Artificial means for the arrest of hemorrhage are therefore quite necessary in this region. The application of a ligature in the ordinary manner is often impracticable, and if coaptation and suturing do not suffice, a ligature must be passed through the scalp by means of a needle in such a manner as to surround the bleeding point (circumsuture), and must be tightly tied. This suture may be so applied as to avoid puncturing the skin, and thus there is no risk of infection from that source. Oozing from the edges of the wound after suturing may usually be arrested by a snugly applied bandage holding the dressings in position. The solid bone beneath admits of the application of considerable pressure.

Fig. 236.—Avulsion of the Scalp.

Contused wounds, though produced by a blunt object, because of the tense state of the scalp and the presence of the smooth bony wall of the skull in close proximity, resemble incised wounds at their edges. The rupture of the vessels, however, is quite irregular or ragged, thus favoring coagulation of blood and spontaneous arrest of hemorrhage.

It was formerly the custom to permit such wounds to close by granulation, on account of the fear of extensive suppurative inflammation of the scalp. With aseptic or antiseptic wound treatment, however, contused and lacerated wounds, after their edges have been trimmed with the knife or scissors, may now be sutured at once.

Avulsion of the Scalp.—This usually occurs in women from machinery accidents, the long hair becoming entangled between the belt and the pulley of shafting or of a machine. The avulsion may be partial; usually, however, the entire scalp is torn from the head, leaving the pericranium exposed. All or portions of the ears and upper eyelids, as well as the integument and subcutaneous connective tissue of the back of the neck, and portions of the temporal muscles, may be included in the avulsion (Figs. 236 and 237). The cranial bones may be denuded of periosteum in places. The degree of shock present and the amount of blood lost vary greatly. Death may result from these causes alone. Where the periosteum is torn off, exfoliation of bone usually takes place.

Treatment.—These accidents most commonly occur in anemic and poorly nourished factory operatives. The loss of blood, together with the prolonged drain on the system incident to the constant oozing of serum from so large a granulating surface, demands that the period of healing be shortened as much as possible. For this reason the surgeon should not await the results of nature's efforts before interfering, but, on the recovery of the patient from the shock, he should at once commence the treatment by skin-grafting. The method of Thiersch should be employed. The strips are to be taken from the outer portions of the thighs as long as these regions are available; subsequently they may be taken from the legs and arms. In the beginning the strips should be placed adjacent to the skin edges, and successive strips placed in position from time to time, with as little time intervening as possible. Care should be taken not to imperil the vitality of the strips by too tight bandaging. This is particularly likely to occur beneath the circular or occipitofrontal turns of the head bandage.

Fig. 237.—Avulsion of the Scalp.

Simple loosening of the scalp without avulsion may occur from force applied in the same manner as in the case of avulsion, the force, however, stopping short of actually tearing away the scalp. This is followed by extensive hematoma of the scalp. Moderate compression by means of a bandage usually suffices in the treatment.

Inflammation Following Injuries of the Scalp.—The tissues of the scalp are not specially disposed to inflammation. When an inflammatory process follows an injury, in the case of the skin covering, it assumes an erysipelatous character; in the connective tissue it is phlegmonous. In preaseptic times the former was of very frequent occurrence after sutured wounds of the scalp; now, however, it is comparatively rare.

A special feature of erysipelas attacking the scalp should not be lost sight of. The redness observed in other localities as one of the symptoms of erysipelas is here replaced by a pale edematous swelling which spreads to the lower margins of the scalp. This is probably due to the fact that the tension of the tissues of the scalp pressing on the bony wall beneath prevents the overfilling of the capillaries. For this reason an edematous, puffy state of the scalp, accompanied by a rigor and elevation of temperature, should be looked on with suspicion as the possible initial stage of an attack of erysipelas.

The special danger to be apprehended from erysipelas of the scalp is the occurrence of **traumatic meningitis** (see page 457). The cortex of the brain may finally take part in the inflammatory process (**encephalitis,** see page 458). A fatal termination is the rule in these cases, delirium and coma supervening.

A fatal **septic meningitis** may also follow a **phlegmonous inflammation** of the connective tissue between the aponeurotic structures of the scalp and the cranium. Here the direct communication between the veins in this region and those of the diploe, and between the latter and those of the cerebral membranes, favors infection by thrombosis. The thrombi, after putrefying and softening, may become displaced and finally be transported to distant parts, causing a fatal **pyemia.** The occurrence of phlegmonous inflammation is recognized by the extreme edema, the scalp pitting on pressure and giving rise to acute tenderness and severe pain accompanied by high fever. Fluctuation is not usually present.

Phlegmonous inflammation and erysipelas may be combined here as elsewhere. When the erysipelas reaches the lower margin of the scalp the skin becomes reddened. Phlegmonous inflammation is soon followed by suppuration. In the early stages the two cannot be differentiated.

Treatment of Wounds of the Scalp.—The importance of a strict antiseptic procedure in cases of scalp wounds cannot be overestimated. Estländer has shown by a careful study of the subject that in preantiseptic times the mortality from this class of injuries was 23 per cent. With antiseptic wound treatment this mortality has been reduced to 1.5 per cent. While the general rules governing the treatment of wounds will here apply, there are some special points to be noted in this connection. In the first place, a large area of the scalp in the neighborhood of the wound must be carefully shaved. Without this precaution it is next to impossible to cleanse the scalp so thoroughly as to prevent bacterial infection. Moreover, exact coaptation of the edges of the wound, as well as the accurate application of dressings, is impossible in the presence of the hair.

All traces of dirt are to be removed by the brush, soap, and hot water, and copious irrigations practised before suturing. As a final measure, germicidal solutions employed for irrigation are to be washed away by means of sterile water or a sterilized normal sodium chlorid solution. The best suture materials for this purpose are horsehair and crin-de-Florence or silkworm-gut. The interrupted suture should be used. In cases in which there is considerable oozing from the skin edges, the suture should always include the entire thickness of the scalp.

If the injury is the result of an accident and the case comes to the surgeon's hands shortly after the accident, and if no special infection is suspected, wounds involving the entire thickness of the scalp may frequently be entirely closed without risk. But, as a rule, drainage should be provided for. This may consist simply in leaving the lowermost angle of the wound open for a quarter of an inch or more. In large, flaplike wounds resulting from glancing blows, in which infection is always to be suspected, the center of the place of attachment of the flap is to be selected and a counter-opening for drainage made at this point. Narrow strips of oiled silk protective make an excellent drain in these cases.

Wounds made in the course of an aseptically conducted operation are always to be closed without drainage.

When dressings are applied to wounds of the scalp they should include the entire head after the wound and neighborhood (which should also be shaved) have been completely covered by separate pieces of sterile gauze. A recurrent

double roller or capeline bandage (see page 404) to secure the dressings in place, and a bandage of starched crinoline, thoroughly wetted and squeezed out before being applied, serve to complete the dressing. The starched crinoline, on drying, will hold the dressings firmly in position, even in the most restless patient. This is a commercial article and is sold in the dry-goods stores for dressmaking and tailoring purposes. Dextrin and glue enter into its composition.

Careful thermometric observations will warn the surgeon of the supervention of a septic condition. Erysipelas and phlegmonous inflammation should be recognized early, and on their occurrence prompt measures of treatment should be instituted (see Treatment of Erysipelas, page 179). In case of phlegmonous or suppurative inflammation the dangers of **pyemia** and **septic meningitis** are imminent; free incisions should be made, followed by the vigorous application of the sharp spoon to clear out suppurating foci. The wounds are subsequently to be packed with gauze wrung out of 1 : 2000 mercuric chlorid solution in 50 per cent alcohol. It is also useful to cleanse the wound thoroughly with a 5 per cent zinc chlorid solution and pack it afterward with gauze wrung out of the same. Even in those cases in which most or all of the scalp has been torn off by machinery accidents a favorable result may be expected. The large granulating surface, after it has assumed a healthy aspect, should be covered in by the application of strips of skin transplanted after Thiersch's method (see page 331).

Tumors of the Scalp.—Atheromas or sebaceous cysts of the scalp, sometimes called wens, are the tumors most commonly found in this location. They differ from dermoid cysts in that the latter are always congenital and limited to certain localities, while the former occur almost exclusively in adults and on almost any portion of the scalp. A differential diagnosis of these tumors will be facilitated if their location is taken into consideration. The favorite sites for **dermoid cysts** are, in order of frequency of occurrence of the cysts, the external portion of the supraorbital arch, the point where the sagittal and coronal sutures join, the site of the anterior fontanel, behind and in front of the auricle.

Dermoid cysts, when uncomplicated by bony defects, as well as sebaceous cysts, are to be extirpated when, because of their size or from any other cause, they become sources of discomfort. The best method of accomplishing this is to make a semicircular incision at the base, turn back a flap which shall include the entire cyst and its contents, and then dissect the cyst from the flap. In this manner the cyst does not, as a rule, rupture, and, what is of greater importance, the entire sac is removed. Dermoid cysts in the neighborhood of the fontanel are frequently complicated by an opening into the cranial cavity, which necessitates extreme care in their removal.

Aneurism of the Scalp.—This may appear either in the shape of a circumscribed saclike dilatation of a portion of a single vessel, or a diffused cylindric dilatation of a number of the arteries of the scalp. The first is usually due to injury of the wall of the vessel, and not infrequently develops in the recent cicatrix after a punctured or glancing wound. Extirpation is the only resource. Care should be taken not to mistake a highly vascular sarcoma of the scalp for an aneurism of this kind. Sarcoma of the dura which has perforated the bone may likewise simulate aneurism.

Cirsoid or **racemose aneurism** occurs almost exclusively in the arteries

of the scalp (see page 94). These are increased in both circumference and length, the latter circumstance producing a serpentine course and wormlike appearance, which are quite characteristic of the disease. Its origin has been attributed to congenital conditions (capillary angioma), to vasomotor paralysis, and to injury.

Varices of the scalp have also been observed (**cephalohematocele** of Stromeyer), and **venous cysts** situated on the line of the sagittal suture and communicating directly with the longitudinal sinus.

In the **treatment of cirsoid aneurism** many difficulties present themselves. Injections of solutions of perchlorid of iron have been tried with fatal results from too extensive coagulation and extension of this to one of the sinuses. The application of caustics has been followed by fatal hemorrhage on separation of the slough. Ligation of the external carotid artery of both sides has been followed by recurrence, owing to the free anastomosis of the arteries of the scalp with the vertebral from the subclavian through the circle of Willis to the frontal, supraorbital, and internal carotid and facial branches. Dieffenbach proposed repeated excision of fusiform portions of the scalp, each wound as it is made being grasped by clamp forceps or the finger of an assistant, hemorrhage being thus held in check until the application of close and accurate suturing. The wound having healed, a second portion is to be excised, and so on, until a sufficient amount has been removed to cure the disease. Total extirpation of the entire aneurismal area followed by immediate correction of the defect by skin transplantation holds out the best hope of cure. An elastic tourniquet should be passed around the head to hold the bleeding in check during the operation (see page 339, Prophylactic Arrest of Hemorrhage). In cases of extensive involvement of the scalp, on account of the danger of death from hemorrhage, the method of total extirpation at a single sitting is an exceedingly hazardous one.

Lipoma of the scalp occurs only in the low occipital region. **Fibromas** are limited, as a rule, to the frontal region, and are usually the result of hat pressure; they occur as hard and painful tumors. Fibromas are sometimes simulated by sebaceous cysts which have undergone calcification.

Sarcoma of the scalp is an exceedingly rare affection. It has been observed most frequently in the occipital region. Recurrence in the cicatrix after removal is the rule. Carcinoma may occur as rodent ulcer or as proliferating epithelial carcinoma, is usually confined to the frontal region, and may appear at the site of a suppurating sebaceous cyst.

THE CRANIAL BONES

Contusions of the cranial bones as described by the older surgeons and considered as indications for trephining because of resulting necrosis are at the present day admitted only as possibilities.

FRACTURES

Fractures of the cranial bones constitute 2.75 per cent of all fractures (Gurlt). The bony walls of the cranial vault are more or less compressible

in both the fronto-occipital and the biparietal diameter. The vertical diameter can also be slightly altered by pressure without fracture. Experiments have shown that the bone almost invariably gives way in the line of pressure, *i. e.*, transverse pressure gives rise to a transverse fracture and longitudinal pressure to a longitudinal fracture.

Fractures of the cranial bones may be the result of **direct** or **indirect** force; fractures from direct force are the more common and their mechanism is very simple. Fractures from indirect force result from the transference of the force to the skull through the medium of the vertebral column, as, for instance, when the patient falls from a considerable height and strikes on the feet. One or more fractures of the base may follow, these radiating from the foramen magnum. Or, if the fall is on the vertex, the compressibility of the skull in this direction is easily exceeded, but the diploe acting somewhat as a buffer, protects the vault and the force is transferred to the more rigid and unyielding base, which is usually fractured at a point opposite the place of impact. These fractures are called fractures by **contrecoup.**

Fractures by contrecoup were formerly believed to be very common and were thought to be the result of vibrations passing around the cranium and meeting at the point at which the fracture occurred. They are now believed to be due to changes in the shape of the skull through the compressibility above referred to, the point opposite that at which the blow was received altering in shape to a less extent than the rest of the bony casing, and hence giving way. Even perforating forces may produce a second fracture opposite the point of entrance of the bullet or other missile, the latter not reaching the point at which the second fracture is found.

Fractures of the skull assume various forms, according to the degree of force and the shape of the impinging object. A sharp-edged or pointed object will be likely to produce a splintered or **comminuted** fracture; one of a somewhat larger surface, a star-shaped or stellated fracture; while a still broader surface, such as the pavement, coming in contact with the skull may produce one or more simple fissures. These fissures may be very extensive, taking a course circumferentially, transversely, or longitudinally, and dividing the cranial encasement into two portions. At the moment of their occurrence they gape considerably, but close again, imprisoning portions of the aponeurosis and even of hair when the fracture is complicated by an external wound (compound fracture). The basilar artery has been found thus imprisoned. When the bone is forced inward to a greater or lesser extent this constitutes a **depressed fracture.** The entrance of the vulnerating object, such, for instance, as a bullet or a knife-blade, gives rise to a **penetrating or punctured fracture.** The latter is always a **compound complicated fracture** and **comminuted** as well. All fractures of the cranial vault, including simple fissure, stellated fractures, and depressed fractures of greater or lesser extent, may be complicated by an external wound (compound fracture). Certain fractures of the base may also be compound, such, for instance, as result from perforation of the roof of the orbit, as well as those in which a fracture of the vault complicated with an external wound extends to the base. While a fracture of the vault may extend to the base, yet by far the greater number of combined fractures of the base and vault take the opposite course, *i. e.*, the fracture extends from the base to the vault. A fracture of the anterior fossa communicates with the air through the nasal cavity and

a fracture of the middle fossa through the auditory canal. This particular feature of these fractures is frequently overlooked. They constitute a most dangerous class of injuries.

In comminuted fractures the tables of the skull do not partake of the splintering process to the same extent. This occurs most frequently at the internal table because of the fact that the greater number of skull fractures are produced by violence originating from without. In cases in which the force is applied from within, as, for instance, where a bullet passes entirely through the skull, while the point of entrance will show the greatest amount of splintering at the internal table, the point of exit will reveal exactly the reverse. It therefore must be apparent that the formerly accepted theory, that the brittleness of the internal table accounts for the more general occurrence of splintering at this point, is incorrect. In the usual form of injury from without inward, the internal table is splintered more than the external table, simply because the latter is affected only by the force which is applied, while the former suffers from this plus the effect of the external table driven against it.

Fracture of the internal table may occur, the external table escaping. This is due to the curved shape of the cranial vault. The molecules of the bony structure are condensed on its convex surface, while the force, transmitted to the concave or inner surface, produces separation there. After the fracture of the internal table the outer unbroken table returns to its normal position.

Traumatic separation of the sutures of the skull occurs, with or without fracture. Separation without fracture takes place almost exclusively at the base. Extensive fissures of the vault may communicate with one or more sutures, the line of force following the latter for a greater or lesser distance, subsequently leaving this sometimes at a right angle and ending on the surface at a place quite remote from the point where it began.

Fractures of the base are almost necessarily of the fissured variety, except those in which the cavity of the skull is invaded directly, as by a bullet or other foreign body. These fissures may pass in almost any direction or invade any locality. The wings of the sphenoid bone and the pyramids of the petrous portion of the temporal bone may be considered as two systems of braces which cross the base of the skull in a transverse direction. Fissures of the base pass in a direction either in front of or behind these. Transverse fissures are more common than longitudinal ones, for the reason that a much greater force is required to produce the latter. In the posterior fossa the fissure frequently involves the edge of the foramen magnum, crossing the latter, as it were, and passing in the direction of the lambdoidal suture. Or, it may cross the sella turcica of the sphenoid and reach the middle fossa, thence turning in the direction of the squamous portion of the temporal bone and the greater wing of the sphenoid. Again, a short longitudinal fissure may communicate with the transverse fissure, pass into the anterior fossa, and invade the ethmoid bone at its horizontal plate, passing to the crista galli. Finally, the fracture not infrequently passes along the anterior edge of the petrous portion of the temporal bone and crosses the tympanum.

Diagnosis of Fracture of the Skull.—The signs usually present in fractures elsewhere are not available for diagnostic purposes in uncomplicated fractures of the skull. Crepitus cannot be obtained and preternatural mobility is absent. Even depressed fracture is frequently difficult of recognition, owing

to the effusion of blood between the soft parts and the bone. The hemorrhage is frequently so distinctly circumscribed as to mislead the surgeon and cause him to mistake the unresisting soft area with sharply defined solid margins for a depressed or even a penetrating fracture. He should also be on his guard against error arising from mistaking old injuries, syphilitic diseases with loss of bone substance, etc., for depressed fracture. So, too, the dishlike depression in the parietal regions resulting from atrophy in old persons may give rise to similar error.

In fractures of the skull complicated with an external wound no difficulty is experienced in making the diagnosis, except that care should be taken not to mistake a suture line for a fissure. The Wormian bones, situated at the posterior extremity of the sagittal suture, should likewise be borne in mind. The point of the disinfected finger is preferably employed for exploratory purposes and the finger-nail will usually reveal the existence of even a fissure. Where the external wound is not sufficiently large to permit satisfactory exploration, it should be enlarged to permit inspection of the fracture. It is unnecessary to state that all manipulative procedures should be preceded by the strictest aseptic precautions. The possible existence of a fracture by contrecoup at a point opposite the place at which the blow was received should be borne in mind in making the diagnosis. The justifiability of converting a simple fracture into a compound one, by incising the scalp for exploratory purposes, will depend on the presence or absence of cerebral symptoms.

Fractures of the base, except in those cases in which fracture of the roof of the orbit or of the auditory canal results from direct force, are not amenable to diagnosis by either inspection or palpation. Another exception relates to those instances in which the patient falls from a height and strikes on the point of the chin, the inferior maxilla being driven through the glenoid cavity of the temporal bone. In fractures of the base reliance is to be placed on the following signs: (1) hemorrhage from one or both ears with or without discharge of cerebrospinal fluid; (2) hemorrhage from the nasal and pharyngeal cavities; (3) subconjunctival hemorrhage; (4) paralysis of individual nerves at the base of the skull.

Hemorrhage from the Ears.—This may occur from other causes, such as injuries to the external auditory apparatus and rupture of the membrana tympani. When due to fracture, the latter runs along the line of the pyramid of the petrous portion of the temporal bone, and the blood, mingled with cerebrospinal fluid, escapes externally through the ruptured membrana tympani. After cessation of the hemorrhage cerebrospinal fluid may continue to pour from the ear in large quantities. This fluid, though rarely, may escape from the nose and the pharnyx. If it is collected in a vessel, the presence of sugar can be demonstrated (Claude Bernard). It is also characterized by an extremely small amount of albumin and a relatively large amount of sodium chlorid. The existence of a considerable pressure—that of the circulation—is proved by this discharge. The quantity of fluid may be increased by the occurrence of venous congestion, such, for instance, as that which results from attempts at forced expiration with the mouth and nostrils closed.

Hemorrhage from the Nose and Pharynx.—A line of fracture running through the ethmoid bone will give rise to hemorrhage from the nasal cavity. Hemorrhage into the pharynx may have its origin in a fracture of the body of

the sphenoid bone and rupture of the mucous membrane, or it may find its way into the pharynx from the cavity of the tympanum through the Eustachian tube. Fatal asphyxia has resulted from profuse hemorrhage in the latter situation, the blood passing down the air-passages (König).

Subconjunctival Hemorrhage.—This symptom does not always appear at once, and several days may elapse before it is observed. In estimating its importance direct injuries to the palpebral and sclerotic conjunctiva must be excluded. This symptom is not so generally present in fracture of the base as has been supposed. In 8 out of 23 cases it was absent (Prescott Hewett).

Paralysis of Individual Nerves.—In fractures involving the petrous portion of the temporal bone the facial nerve may be injured as well as the auditory. It is claimed that one-fourth of all the fractures of the base involves injury to these nerves (König). Fractures involving the semicircular canals may give rise to the vertigo observed in Ménière's disease of the labyrinth; in fractures of the base this is usually due to injury of the cerebellum. Paralysis of the motor oculi, trochlear and abducens, either from pressure resulting from hemorrhage or from contusion, is rather rare; strabismus, double vision, etc., are characteristic symptoms of paralysis of these nerves. Visual disturbances resulting from fractures crossing the optic foramen, and contusion of the optic nerve or hemorrhage within its sheath, are also observed. It not infrequently happens that not more than one or two of these symptoms of fracture are present in a single case. Very rarely in cases of extensive fracture at the base all of them may be observed.

Traumatic Cranial Hydrocele or Pseudomeningocele.—Compound fractures of the lower portions of the frontal bone sometimes give rise to the escape of cerebrospinal fluid in considerable quantities. In children in whom there exists a high degree of intracranial pressure as well as a large relative amount of cerebrospinal fluid, the latter may escape from fractures in the locality just indicated, without external wound. This fluid collecting thus beneath the scalp constitutes the so-called cranial hydrocele or pseudomeningocele. Pulsation may be present in the tumor, and the latter has been shown to be connected directly with the lateral ventricle. Any attempt to open these collections of cerebrospinal fluid should be accompanied by the most rigid asepsis.

Cerebral Complications in Injuries of the Skull.—Concussion of the brain may occur without fracture of the skull, or even marked contusion. Considerable disturbances of function follow. The symptoms consist of loss of consciousness, either partial or complete; pallor; small, feeble, and slow pulse; vomiting. The condition is to be considered as a temporary inhibition of the brain centers, mechanically produced. H. Fischer suggests that the symptoms are the result of a reflex paralysis of the heart and vessels, in which the cerebral vessels likewise share. Stromeyer believed the condition to be simply one of cerebral anemia, arising from compression of the skull forcing the blood from the brain. The forcing of the cerebrospinal fluid through the aqueduct of Sylvius and against the floor of the fourth ventricle has also been suggested to account for the symptoms (Duret). The duration of the symptoms varies with the severity of the injury. Vomiting occurs but once, as a rule. Consciousness generally returns shortly after the occurrence of vomiting,

but it may be delayed for several hours; exceptionally, days may elapse before it is entirely restored. It is probable, in those exceptional cases in which the return to consciousness is delayed beyond a few hours, that punctated hemorrhages have occurred. The vasomotor disturbances, the pallor, and the small, weak, and slow pulse disappear in a short time and are followed by a directly reverse condition; the face becomes reddened and hot and the pulse full and strong. This is called the **stage of reaction.** Diabetes mellitus, diabetes insipidus, polyuria, and albuminuria have been observed as sequels of concussion of the brain. The explanation of the phenomena that has been hitherto offered has not proved satisfactory. Claude Bernard's well-known experiments in the production of glucosuria by irritation of the floor of the fourth ventricle form the basis of the most plausible theory for their occurrence.

Compression of the Brain.—The chief causes usually assigned in the production of compression of the brain following injury are: (1) effusion of fluid within the cranial cavity; (2) pressure from without by displaced bone. The former is the more important, though it is not always easy to separate the symptoms of compression from those of concussion in cases in which considerable contusion occurs at the site of the depressed bone. Simple depression of the cranial bones in the limited area in which it is usually met is quite unlikely to give rise to the grave symptoms which so commonly occur in compression, unless the brain itself has been injured. The symptoms which occur are believed to be due to the recession of the cerebrospinal fluid from the space which it occupies between the arachnoid and the pia mater in the interval between the two hemispheres at the base of the brain, into the general ventricular cavity by the opening of the inferior boundary of the fourth ventricle, and into the spinal subarachnoidean space as well (Bergmann and Althann). The effect of this recession is to remove the mechanic support given by the cerebrospinal fluid to the nervous centers at the base where the large vessels of the brain enter, and to permit direct systolic impressions on the cerebral mass. If this recession is sufficient to fill the connective-tissue spaces within the sheaths of the nerves, lymph-vessels, and veins with which the subarachnoidean space communicates, the essential symptoms of cerebral anemia are present (Bergmann).

According to Kocher, when the circulation of the brain is interfered with by an increase of intracranial tension a compensatory rise of blood-pressure takes place, this equaling or slightly exceeding the extravascular pressure compressing the cerebral vessels. In case the latter exceeds the compensatory rise a fatal bulbar anemia ensues. Kocher divides the clinical phenomena of cerebral compression into the following stages: (1) The stage in which there is but slight encroachment on the intracranial space and compensation is accomplished by displacement of cerebrospinal fluid, and possibly by changes in the lumina of the venous channels. In this stage the symptoms are comparatively slight. (2) The stage in which there is an obstruction to the return circulation, in which choked disk and the phenomena of cerebral irritation (headache, vertigo, restlessness, delirium, etc.) occur. (3) The stage in which the extravascular compression is so great as to give rise to functional disturbances through the anemia of the brain which results. This anemia may be general or local, according to the extent of area of the brain involved in the compression, the symp-

toms varying accordingly. In cases in which the compression is extensive, with involvement of the medulla, symptoms of general compression supervene. It is in this stage that a reflex stimulation of the vasomotor center and a compensatory rise of blood-pressure occur, the effect of which is to balance the intracranial tension and restore the equilibrium between the extravascular pressure of the cerebral vessels and their intravascular pressure. Upon the extent to which this is accomplished will depend the restoration and maintenance of the cerebral circulation. As the conditions present in the second stage alternate from time to time with those of the third stage, the symptoms will vary accordingly, such as alterations in the size of the pupils, rhythmic respiratory disturbances (**Cheyne-Stokes respiration**), and varying degrees of cerebral irritation and stupor. (4) The stage in which the characteristic features are failure of compensation of the intracranial tension, rapid fall in the blood-pressure, and a condition of continuous cerebral anemia, with consequent inhibition of the functions of the cerebral organs.

In all cases of injury of the head the blood-pressure should be carefully estimated from time to time, and the knowledge thus obtained made use of, particularly in cases in which other evidence is not available, in determining the advisability of operative interference to relieve compression.

For compression resulting from the presence of pus, see Cerebral Abscess, page 460.

Hemorrhage into the cranial cavity is to be considered as almost the sole cause of cerebral compression. Further, in the great majority of cases of hemorrhage from head injuries the source of the hemorrhage has its origin in one or more branches of the middle meningeal artery. The anterior or large branch is the most frequently involved. Prescott Hewett found that among 31 cases of intracranial hemorrhage from injury, the extravasation being between the dura and the bone, in 27 the origin of the hemorrhage was the anterior branch of the middle meningeal. It crosses the great wing of the sphenoid and passes to the groove or canal at the anterior inferior angle of the parietal bone before giving off any branches; at this point it is most easily reached for purposes of ligation.

Fracture need not necessarily occur in order that rupture of the vessel may take place. Simple and temporary compression of the cranial bones, the latter returning to their normal shape after the removal of the force, suffices to rupture the vessel. Usually, however, the vessel is ruptured by a fissure crossing its track. This is favored by its close and unyielding attachment to the dura; the latter circumstance is also an important factor in preventing the spontaneous arrest of hemorrhage.

Hemorrhage from other intracranial vessels is also observed, though rarely. The internal carotid may be torn across its track by a fracture as it passes through the petrous portion of the temporal bone. The basilar artery has been known to be involved in a fracture of the occipital bone. (For special varieties of intracranial hemorrhage see page 456.)

The rapidity with which symptoms of compression supervene after the occurrence of the injury will depend on (1) the size of the vessel injured; (2) the force of the circulation; (3) whether or not the extravasated blood escapes from the cranial cavity. This sometimes forces its way through the fissure, and in the case of a simple fracture effuses itself beneath the scalp and there

forms a large coagulum. If the fracture is complicated by a wound of the scalp the blood may escape externally. These conditions will delay and perhaps prevent altogether the occurrence of symptoms of compression. Though, as a rule, the latter are quite distinctive within a few hours, in rare instances several days elapse before they develop sufficiently to warrant interference.

The pressure, as a rule, involves but one hemisphere. Occasionally, however, the blood finds its way from one parietal region to the other, forming a semicircular broad band of coagulum across the vertex. When but one hemisphere is involved in the pressure, a paralysis of the upper and lower extremity of the opposite side is manifest, which may be preceded by a short stage of involuntary muscular twitching; true convulsions may occur. The pulse is almost invariably diminished in frequency, being sometimes as low as 40 beats to the minute or lower; this is one of the most constant symptoms and seems to bear no particular relation to the part affected by the compression. The sensorium now suffers in a most decided manner; unconsciousness slowly supervenes until coma develops. Finally the respirations grow less and less frequent and life is gradually extinguished.

The differential diagnosis of concussion of the brain and compression of the brain offers no special difficulties. In the case of the former the manner of invasion is sudden, while in the case of the latter it is a comparatively slow process. In concussion the pulse, though it may become slow, is likewise feeble, while in compression the lessened pulse-rate is not marked by a corresponding diminution of force. In concussion the pallor of the surface is marked, while in compression the natural color is maintained. The respiratory act is not affected in concussion, while in compression the vagus center is affected most decidedly. In concussion the pupils generally respond to light, though they may be unevenly contracted, while in compression they are fixed, usually dilated, and do not respond to light. The only symptom common to the two conditions is that of unconsciousness, and the manner in which this occurs differs so greatly that there is scarcely room for error when a proper history of the case can be obtained.

Hemorrhages from the Sinuses of the Dura Mater.—These large venous channels may be injured and yet the patient may recover. Schellmann's experiments on dogs show that but slight pressure is necessary to restrain hemorrhage from this source. Fatal hemorrhage from the transverse and cavernous sinuses has occurred, however. In extreme anemia of the brain together with marked diminution of the cardiac impulse aspiration of air may occur, when, for instance, the longitudinal sinus is opened and exposed. Hemorrhage from the superior longitudinal sinus in fracture of the vertex, and from the lateral sinuses in fractures of the occipital bone, may be held in check by the presence of depressed bone. On the elevation of the depressed portion the hemorrhage will appear at the opening. Under these circumstances, rapid removal of the fragment and the prompt application of a clamp or hemostatic forceps is indicated. In making forcipressure, one blade of the clamp passes within the cranial cavity and forces the bleeding sinus against the inner surface of the bone, while the other blade rests on the outer surface of the bone. Should the size of the opening preclude this procedure, the opening should be rapidly enlarged. The finger passed through the opening in the skull will of itself hold the bleeding in check, while by means of Keen's gouge forceps (see Fig. 91)

this opening is enlarged and the opening in the dura is also increased in size, if necessary, with the scissors. The clamp, once satisfactorily in position, should not be disturbed for from twenty-four to forty-eight hours. An excellent and expeditious method of stopping hemorrhage from a bleeding sinus is to make firm pressure in the wound by packing with compresses of iodoform gauze.

Contusion and Laceration of the Brain.—These are not infrequent accompaniments of injuries of the cranial bones and are to be classed with the most important of the complications of these lesions (see page 455). In cases in which compound fracture with depression occurs to an extent sufficient to permit brain matter to escape, the latter exudes as a pulpy mass more or less mixed with blood.

Clinical Course of Simple Fractures of the Skull.—Uncomplicated fractures of the skull pursue the same uneventful course as simple fractures elsewhere. A noticeable feature is the **small amount of callus produced during the processes of repair.** This is to be ascribed to the immobility of the fragments and the consequent very slight irritation present. This also explains the absence, as a rule, of symptoms of cerebral irritation such as would follow the presence of deposits of new bone on the inner surface of the cranial bones. Cases occur, however, in which disturbances of function result from the formation of bony deposits in this location; operative procedures are necessary for the relief of these. **Complete regeneration** following losses of bone, either from accidental injury or from the use of the trephine, almost never occurs. The dura mater here assumes the function of a periosteum, though but to a minor extent, as shown by the fact that excessive formation of callus under these circumstances is almost unknown.

In simple uncomplicated fractures of the cranium repair takes place without any treatment other than the protection afforded by the unbroken scalp. Minor disturbances of the cerebral tissue likewise require no further care aside from that embraced in the expectant plan. Should symptoms of concussion persist, however, beyond those of a simple and temporary "stun," stimulating treatment should be instituted, such as application of artificial heat, the administration of hot alcoholic drinks in small quantities, by the mouth if the patient can swallow, otherwise through the rectum. Hypodermic injections of camphorated ether, inhalations of aqua ammoniae to stimulate the heart, and sinapisms to the surface of the extremities are also useful. The hypodermic injection of $\frac{1}{100}$ of a grain of sulfate of atropin to increase the arterial pressure, and inhalations of nitrite of amyl to lessen the resistance to the passage of blood through the smaller vessels and capillaries, are also useful. Under no circumstances should ice or cold water be applied to the head during this stage. As soon as **reaction** is established all stimulating measures should be abandoned; with **excessive reaction** a new line of treatment is indicated. Fullness of the cerebral vessels, as indicated by the flushed face, congestion of the conjunctiva, and throbbing of the temporals, is to be met by the application of the ice-cap or ice-cold compresses. At the same time, the administration of an active cathartic, such as a powder containing 10 grains of powdered jalap, is a useful adjunct to the local treatment.

The treatment of compression of the brain will depend on its causes. If due to clot, this should be turned out and the bleeding vessel tied if necessary.

If the result of abscess, this should be evacuated. The cause being removed, the brain usually recovers its functions. As a rule, ligation of the vessel after removal of the coagulum is not necessary; the hemorrhage will be found to have ceased. Should it persist, however, removal of a sufficient amount of bone to enable the vessel to be reached will be indicated, and may be effected in a rapid and satisfactory manner by means of Keen's gouge forceps (Fig. 91).

Clinical Course of Compound Fractures of the Skull.—In the absence of infection, union of a fracture of the skull complicated by an external wound progresses in all essential particulars precisely as union of a simple fracture. This is particularly true if primary union of the soft parts takes place. Where union by secondary intention occurs, the reparative process goes on rapidly and cicatrization is soon accomplished. The occurrence of septic infection, however, exposes the patient to grave special dangers, such as erysipelas and phlegmonous inflammation, which may lead to meningeal and cerebral complications. Suppurative osteomyelitis of the diploe and general pyemic infection may also follow.

It was formerly thought that fractures of the skull gave rise to a special danger from metastatic abscesses. It has been shown, however, that there is no greater tendency to this complication in these fractures than in injuries elsewhere.

Pachymeningitis.—The dura mater is not readily disposed to inflammation, owing to its structure. Hence inflammation of this membrane is not a common result of head injuries; when it does occur, it is usually limited to the place of injury. Suppuration between the dura and the internal surface of the skull, however, as well as between the pericranium and the external surface, leads to necrosis; this occurs the more readily when considerable splintering takes place. This suppurative process becomes the more dangerous from the tendency to septic phlebitis and thrombosis of the veins communicating through the dura with those of the pia mater, arachnoid, and encephalon. In the case of the first named, a **leptomeningitis** develops (see page 458). Though the manner of infection described is in all probability the most common, it is not to be denied that suppurative inflammation of both the external and the internal surface of the dura may occur, infection of the arachnoid and pia mater and consequent leptomeningitis arising from contact through the lymph and blood-vessels. The vascularity of the last-named membranes tends to rapid spread of inflammation. Erysipelas may affect the arachnoid and pia mater through the medium of the lymph-channels or blood-vessels. Again, infection may occur from the foreign body which produces the injury, or from portions of head covering or from the hair itself (see Traumatic Meningitis, page 457). Suppurative meningitis is to be considered an absolutely fatal affection.

Treatment of Compound Fractures of the Skull.—The first care of the surgeon should be to protect the wound itself with a gauze compress wrung out of 1 : 1000 mercuric chlorid solution of sufficient size to fill the wound completely. Next the entire scalp must be shaved and cleansed, first with soap and water followed by alcohol, and subsequently with ether; lastly with a 1 : 2000 mercuric chlorid solution in 50 per cent alcohol. The wound itself is now to be cleared thoroughly of all macroscopic dirt and disinfected with the above mentioned mercuric chlorid solution. Stress is here laid on these precautions, though they are described elsewhere, their importance being enhanced in this

connection by the grave complications which follow failure to exercise from the very beginning the greatest possible care in the treatment of this class of injuries. The wound should be sufficiently enlarged to permit proper exploration and the removal of foreign bodies. Ocular inspection should be practised. It is not sufficient to ascertain that a simple fissure exists; hair is sometimes imprisoned in the latter and must be removed. A knife-blade or other pointed instrument may have been driven through the skull and broken off below the level of the bone.

The further operative procedure will be guided by the condition found on exploration. If blood oozes in considerable quantities from the fissure, the cavity of the skull is to be entered by removal of sufficient bone for the purpose.

Fig. 238.—Application of Chisel and Mallet to the Skull in Depressed Fracture.
The skull is exposed through an "X" incision. The dotted lines are intended to show the method of making a large opening in the skull when this is required for purposes other than the removal of the fragments in depressed fracture.

Fragments of bone detached from the pericranium and dura are to be removed. Although the importance of depressed portions of bone in producing symptoms of compression has been very much overestimated, they should nevertheless be brought up to their proper level, for the reason that foreign bodies, hair, as well as loose spiculas of bone, may have been carried down with the edge of the depressed bone. Drainage of the parts is also thus greatly facilitated.

A time-saving method of elevating the fragments consists in chiseling away with a chisel and mallet (Fig. 238) a portion of the undepressed bone at the margin of the depressed portion to an extent sufficient to permit introduction of the elevator (Fig. 239). With the back of the latter resting on the solid edge of the intact bone and its point beneath the fragment, a powerful lever is formed.

and the depressed bone is lifted into position (Fig. 240). It will rarely be necessary to remove fragments permanently in cases in which an aseptic course is expected; even when these are lifted away for purposes of thorough cleansing, they may be frequently replaced with advantage (Ollier, Macewen). When the injury to the cranial bones is quite extensive, and particularly when the wound has been exposed to possible infection for a long time before coming

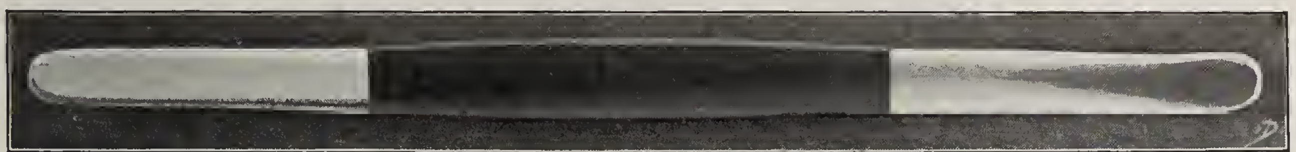


Fig. 239.—Elevator for Elevating Fragments in Fracture of the Vault of the Skull.

under the surgeon's care, the fragments, if detached completely, may be removed. It will scarcely ever be necessary to employ the trephine in cases of depressed fracture. The chisel and mallet, if properly employed, will always fulfil all the indications with less destruction of bony tissue and considerable saving of time.

Even fissures are to be treated operatively in order that the best results

Fig. 240.—Elevation of Fragments.

may be obtained. The beveled edge of the chisel is applied toward the surface of the skull and held in such a manner that the corner of the chisel cuts away the edge of the fissure at an angle. By cutting away both edges in this manner a V-shaped groove is formed which enters the diploe. Drainage of the latter is thus provided for, and all foreign bodies, hair, etc., which may have entered when the fissure gaped widely are thoroughly removed. The V-shaped gouge

may be advantageously employed for this purpose. Projecting edges of bone which prevent elevation of the fragments may also be chiseled away with advantage.

The operative procedure being completed, the wound itself claims attention. This should be treated on general antiseptic principles if infection has occurred. The use of an antiseptic irrigating fluid is rather to be deprecated and is contraindicated if there exists a wound of the dura. If it is employed it should be subsequently washed away with a sterilized salt solution. In place of the irrigating fluid, gauze sponges wrung out of a 1 : 1000 mercuric chlorid solution, a 2.5 to 5 per cent solution of carbolic acid, or a 5 per cent solution of zinc chlorid may be employed, if decided septic conditions are already present. In case of

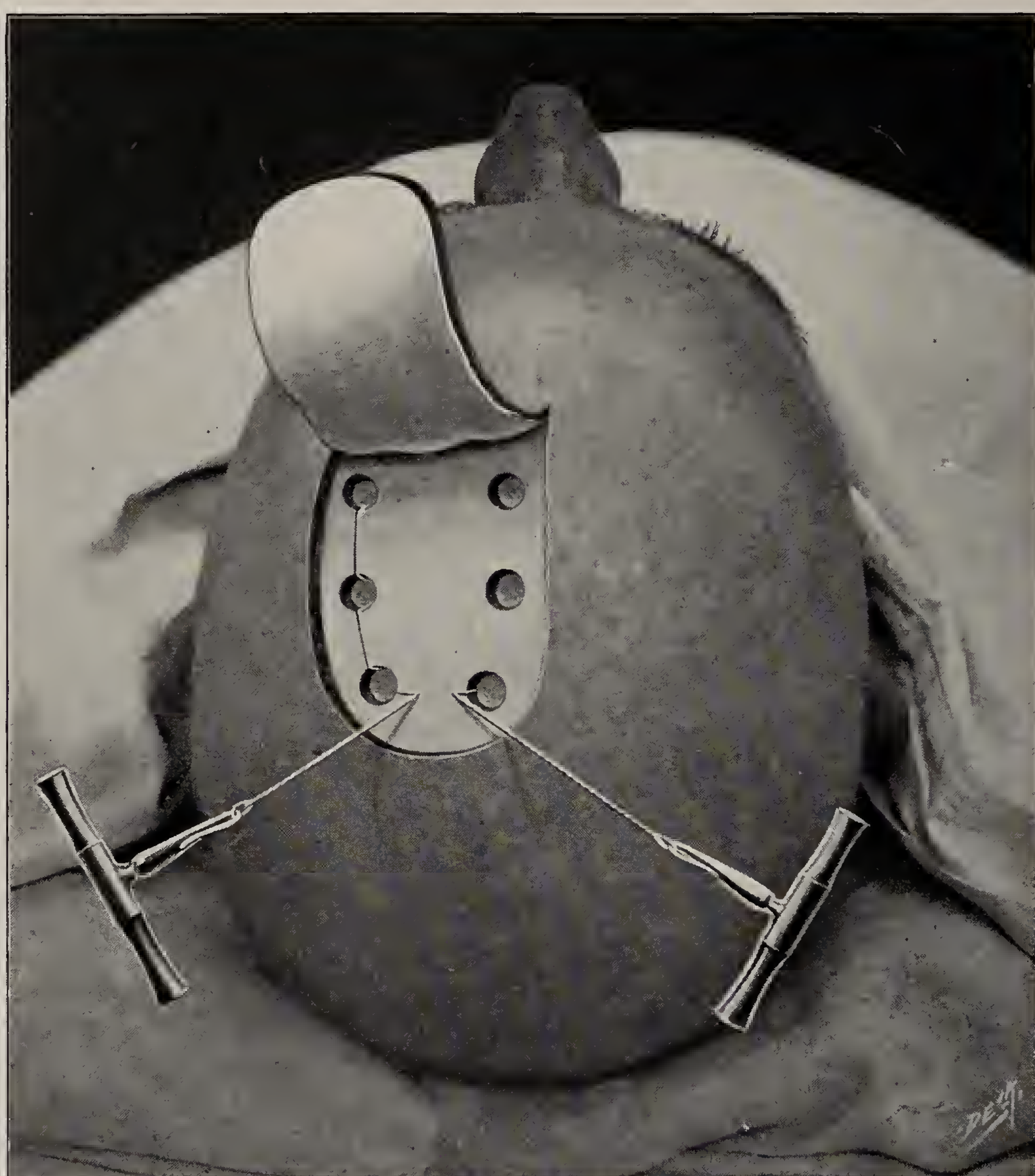


Fig. 241.—Removing a Portion of the Skull with the Gigli Wire Saw.

injury of the brain substance, the last named is considered to be particularly efficacious (Socin). The question of drainage is an important one. The ideal method is to close the wound completely, but this presupposes an aseptic condition of the parts, of which the surgeon cannot always be certain. The gauze drain will fulfil all the indications, if the simple leaving open of the most dependent portions of the wound is not deemed sufficient. If all goes well and no drain has been employed, the wound need not be disturbed for a week or ten days. If a drain has been introduced, this should not remain longer than twenty-four or thirty-six hours, at the end of which time, in the great majority of cases, the wound after being redressed may remain undisturbed for the period of time occupied by the healing process.

In **fractures at the base** purely surgical measures are restricted to those which provide against infection through the nasal cavity in fractures of the anterior fossa, and through the auditory canal in case there is escape of cerebrospinal fluid, in fractures of the middle fossa. The external auditory canal is cleansed with soap and water and a cotton probe, thoroughly washed (not forcibly irrigated) with an antiseptic solution (the borosalicylic solution of Thiersch), and lightly packed with cotton or gauze wrung out of a mercuric chlorid or carbolic acid solution. The nasal cavity is not so readily protected. This should be washed out with a boric acid solution and the anterior nares lightly packed. Plugging the posterior nares produces considerable irritation and increased flow of mucus, which latter offers a still greater opportunity for putrefactive changes and hence sepsis.

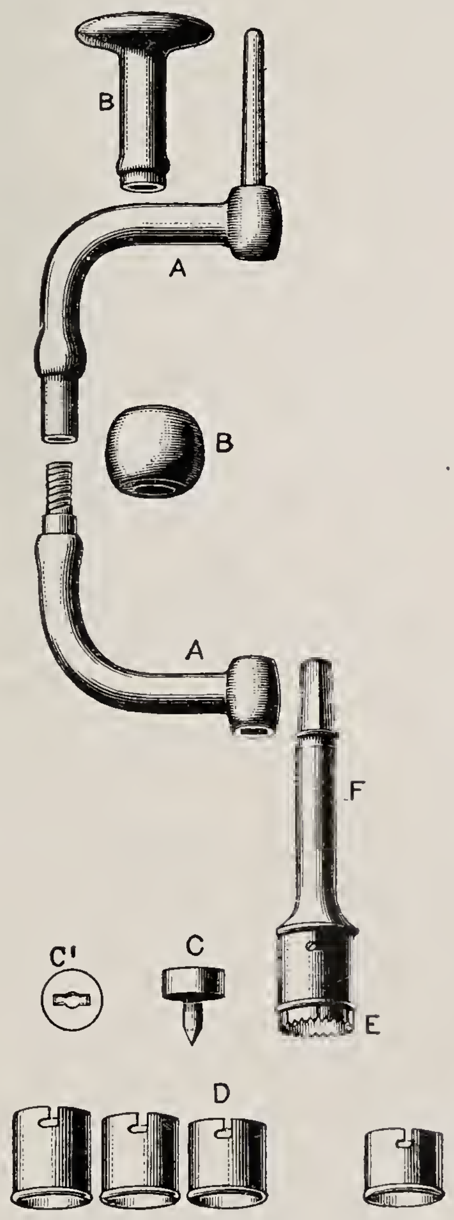


Fig. 242.—The Aseptic Brace Trephine.

A A, Brace; B B, handles; C, pin detached; C′, upper surface of pin showing clutch; D, guard rings detached; E, crown, with guard ring in position; F, stem.

In addition to these measures the patient is to be placed under conditions which shall insure the greatest possible quietude, and the ice-cap applied. The administration of a calomel and jalap purge and the subsequent administration of remedies to control pain, etc., are indicated. The bromids may be tried; the use of opium is not contraindicated and in some cases is useful. In extreme restlessness and delirium doses of $\frac{1}{100}$ of a grain of hydrobromate of hyoscin given hypodermically will be found useful.

Trephining.—The application of the trephine is not so frequently required in fractures of the skull as heretofore, its place being supplanted by the mallet and chisel (Fig. 238) and the Luer or Keen gouge forceps (Fig. 91). In traumatic epilepsy and in brain tumors and brain abscesses the trephine is useful in making the first perforation in exploratory operations.

The method of drilling holes at proper distances and dividing the intervening spaces with the Gigli wire saw also has its advocates (Fig. 241). The incisions necessary to bare the surface of the skull in nontraumatic cases should be U-shaped, the base of the flap being preferably toward the base line of the skull. In cases of fracture of the vault an X-shaped incision is employed in order to permit extension of the incisions in all directions in following up lines of depressed fractures (Fig. 238). The pericranium should be lifted with the flap by means of the periosteal elevator (Fig. 239). Either Galt's conical trephine (Fig. 85), the aseptic hand trephine (Roberts, Fig. 84), or the aseptic brace trephine (Fig. 242) may be employed. The latter with its guard rings insures rapid and safe perforation of the cranial cavity. The method of its application is readily shown in the figure. Several widths of guard rings are furnished (Fig. 242, D). The widest of these, which permits the crown of the instrument to make a simple

groove, is first employed. This, together with the pin, which up to this time has served as an axis on which the crown rotates (Fig. 242, C), is removed, and a narrower ring permitting a still deeper groove is substituted. A turn or two of the brace suffices to bring the trephine to the full depth permitted by the guard ring. As the operator has no fear of unexpectedly perforating the cranial cavity, these movements may be executed boldly and rapidly. The guard rings are changed in a few seconds and the operator has the satisfaction of knowing, first, the exact depth which has been reached; and, second, that the groove is the same depth in its whole extent—advantages which give him greater confidence in his manipulation. The awkward and strained movements which involve considerable muscular exertion, as in the use of the hand trephine, are avoided. Each time the guard ring is changed for a narrower one, the button of bone is tapped with the handle of a scalpel or the elevator to ascertain if it is yet loosened.

Osteoplastic resection of quadrangular plates of bone (J. Wolff), though an ideal procedure, is difficult in its technic. Three sides of the square are grooved to the entire thickness of the bone by a narrow chisel, the scalp not being turned back, but simply incised, and the grooves cut at the bottom of the openings made by the incisions, the edges of the latter being retracted for the purpose. The fourth side of the quadrangle is broken across by prying up the piece; it, together with the flap of the scalp which remains attached to it, is raised up like a trap-door. The same procedure, with an omega-shaped flap of scalp and bone (Wagner), permits a more ready fracture of the base of the bony portion of the flap, the latter being narrower in proportion to the area of the remainder of the flap.

Indications for Trephining.—In addition to enlarging openings in the skull to facilitate the elevation of depressed portions of bone and the removal of fragments (which, as before stated, is best accomplished by chiseling), it becomes necessary to trephine for the removal of foreign bodies. Many of these, however, such as smooth pieces of metal, small pistol balls, etc., remain in the cranial cavity without apparent detriment, provided the patient recovers from the first effects of the injury. Instances are recorded of pistol balls that remained in the cranial cavity for years and were found postmortem, the patients dying from diseases having no connection with the presence of the foreign body in the brain. Large bullets, however, and rough foreign bodies do harm. In exploring for these, after the dura mater has been trephined and incised a light aluminum probe is introduced and permitted by the force of gravity to find its way along the supposed bullet track (Fluhrer). Incision of the brain may also be practised for the purpose of further exploration. The telephone probe (Girdner) will be found to be a useful instrument in locating metallic foreign bodies in the brain as elsewhere (Fig. 64). The Röntgen ray should be used when available.

The treatment of compression arising from hemorrhage from the middle meningeal artery has already been dwelt on. In cases in which no fracture occurs and yet the suspicion exists that rupture of the vessel has taken place from a blow on the side of the head, the bone having from its elasticity sprung back to its normal position without fracture, **trephining** and **ligation of the artery** at the point where it passes to the lateral wall of the cranial cavity are indicated. The anterior branch of the middle meningeal artery can be con-

veniently located as follows: Two lines are drawn at right angles to each other. The one is vertically placed and is located an inch and a half in front of the external auditory meatus; the other is horizontally placed one inch above the edge of the zygoma. The point at which these lines cross each other represents the center of the middle meningeal area. In applying the trephine at this point the extreme thinness of the bone should be borne in mind. A U-shaped flap, which includes in its thickness the skin and temporal muscle, large enough to expose the middle meningeal area, is turned back and a large button of bone is removed; after the clot is turned out the vessel is exposed and secured. The opening, if not already sufficiently large to enable the bleeding point to be reached, may be rapidly enlarged by means of Keen's gouge forceps (Fig. 91). Sometimes the bleeding point can be identified by turning back the dura by means of a spatula. If it is found that the anterior branch is not injured, the source of the bleeding must be sought in the posterior branch by applying the trephine over the parietal prominence. These failing, ligation of the external carotid artery is indicated. In cases of brain abscess, secondary trephining is indicated, to permit the evacuation of pus and drainage. Even the occurrence of suppurative meningitis and cortical encephalitis will permit the application of the trephine, since no better antiseptic or antiphlogistic measure offers. If performed sufficiently early, this may yet prove a rational method of meeting the indications in these otherwise almost necessarily hopeless cases. In focal suppurative encephalitis or brain abscess the diagnostic acumen of the surgeon is taxed to the utmost to determine, first, the existence of an abscess, and, second, its location (see Cerebral Localization, page 466). The trephine opening having been made at the place to which the symptoms pointed as the probable seat of the abscess, even after the use of the exploring needle and syringe no pus may be found. The great mortality of abscess of the brain, on the one hand, and the fact that 50 per cent recover if success follows the effort to locate the same, on the other, will impel the surgeon to persist in his efforts when the symptoms are at all well marked. The sense of fluctuation is not always available in this situation; absence of pulsation, though suggestive, is not to be relied on.

Foreign bodies, producing symptoms of irritation of the brain, may require the operation of secondary trephining. Broken-off knife-blades have been thus removed after the lapse of years. The occurrence of paralysis, epilepsy, and mental disturbances with a history of head injury constitutes an indication for trephining. The site of the injury is usually selected for this purpose. Hueter mentions an instance in which a paralysis of seven years' duration was relieved by trephining at the site of injury. A hyperostosis, together with portions of lead from a pistol ball, was removed. In epilepsy following cranial injury a certain small number of mild cases are improved by simple excision of the cicatrix in the soft parts. Tenderness of the scar is usually present here. But by far the greater number of cases relieved by trephining are those having depressed portions of bone and thickening at the site of the injury. The proliferation may not always be demonstrable until a button of bone has been removed. Though many of the successes reported have been but temporary, yet the impossibility of cure by other means fully justifies the attempt at cure by operative means, when a clear history of injury can be obtained (see Surgical Epilepsy, page 471).

GUNSHOT INJURIES OF THE HEAD

The traumatism of the bullet in this region differs from that arising from any other cause, for the reason that, no matter how apparently slight the injury, the element of concussion always enters largely into the case. The symptoms therefore are those of concussion (even if the bullet does not enter the head), followed by those of fracture, and finally, in severe cases, of laceration of the brain.

The first effects of concussion in gunshot injuries of the head are manifested in the oblongata; the respiratory center is at once inhibited or absolutely paralyzed. The physical influence of the bullet on the encephalic contents is a hydrodynamic one (Kramer and Horsley).

Other centers likewise suffer, their functions remaining suspended until the general effects of the concussion have passed off. In moderate concussion the heart's action may be retarded; in severe concussion, accompanied by laceration of brain tissue, it will be accelerated from paralysis of the vessels and loss of vascular tone.

The missile from a modern rifle will rarely lodge in the cranial cavity, but the ordinary pistol bullet will often do so. Where the bullet enters and emerges the wound is called a **perforating wound;** where the bullet enters but does not leave the cavity of the skull, it is called a **penetrating wound.**

The secondary symptoms of gunshot injuries of the head are of so varied a character as to be entirely untrustworthy in locating the bullet.

In conducting the examination of a case of gunshot injury of the head, when a fracture is found but no evidence of perforation exists, the possibility of the bullet's having entered the cranial cavity between a depressed fragment and the adjoining sound bone, the former having sprung back from its natural elasticity, should be borne in mind (Bergmann). Or a portion of a bullet may pass in this way, the remaining portion lodging beneath the scalp (case in my own practice). Another fallacy may arise from a separation of the bullet into two portions, one portion escaping through an opening of exit, the other remaining. When the bullet enters from the direction of the cavity of the mouth it may lodge in the nasal fossa or in one of the accessory sinuses. It may glance off from the bony structure of the base of the skull at the back of the pharynx and finally lodge in the cavity of the mouth. Or, it may pass either into the esophagus and be swallowed, or through the glottic opening, lodging finally in the larynx, the trachea, or the bronchus.

In gunshot injuries of the facial region the bullet may pass from below through the accessory sinuses and reach the cranial cavity; or it may stop short of the latter, in which case the missile may usually be traced by the telephone probe and its removal effected.

Occasionally a case is observed in which a would-be suicide places the muzzle of a pistol to the ear, in the belief that access to the cranial cavity is more easily effected by this route. In a case of this kind, during my service at the Methodist Episcopal Hospital, an injury of the internal carotid artery in the carotid canal occurred, the walls of which had been crushed in by a bullet, the presence of the latter, however, preventing hemorrhage. Upon removing the missile a violent hemorrhage took place, necessitating ligation of the common carotid artery.

The fallacy arising from the simultaneous reception of other injuries which subsequently give rise to symptoms of intracranial disturbances should not be lost sight of.

The bullet may penetrate the skull and yet not pass through the dura mater. The missile may be found resting on the dura, or lodged between the dura and the inner table of the skull at the site of the wound, or at a point more or less remote from the original point of entry. This may occur in the case of a "spent ball," or one that has lost most of its projectile force immediately after entering the skull. In these cases the bullet may not be accessible to the probe, and may be discovered only by the Röntgen rays or after trephining.

The dura mater may be injured by the splintered fragments of the skull, the latter being driven into the substance of the brain, the bullet assuming an extradural location. The missile may pass but a short distance into the brain substance, where it may be identified after trephining and enlarging the opening in the dura.

When both tables are broken the greatest amount of damage is inflicted on the inner table; this is according to Teevan's law, that the fracture commences in the line of extension rather than in the line of compression, the internal table receiving the force of the bullet, plus the force conveyed by the outer to the inner table. In perforating wounds the force at the point of exit is applied from within and the outer table is more extensively splintered. Hence, the wound of exit is larger than that of entrance.

A bullet in its passage through the skull produces radiating tears of the brain substance, these being more marked in the gray than in the white substance (Tillmanns). In addition to the missile and bone splinters, portions of hair, etc., may be present in the brain substance.

The probable direction taken by the ball, as based on the position in which the firearm was held at the time of the shooting, should be considered, as well as an inspection of the opposite side of the head made for the presence of bulging or other evidences of fracture. The ball may strike the opposite side of the wall at right angles to the surface or within 15 degrees of it and lodge at the point of impact (Ruth). Fluhrer, Delbet and Dagion claim that a ricochet takes place in some cases, the deflected bullet taking a secondary course in the cranial cavity. According to Ruth, when deflection does occur, it is almost invariably at right angles of more than 90 degrees to the angle of incidence.

In **probing** for a bullet lodged in the cranial cavity the instrument used should have a spheric tip, and in order to minimize the friction arising from its contact with the collapsed bullet track and to insure that all resistance to be appreciated by the hand manipulating the probe is communicated from its tip, the tip should be mounted on a slender shaft. For the larger sized missiles a probe tip one-fourth of an inch in diameter will suffice for bullets from .32 caliber up, and one three-sixteenths of an inch in diameter will follow the track of a bullet from one of the smaller firearms. The extreme limit of force employed in the case of the first named, in order to guard against driving the tip of the probe into the brain substance or between the convolutions, is from two and one-half to three ounces (Ruth). In order to determine the exact amount of force employed, the graduated pressure probe may be employed (Fig. 243). The handle of the instrument is hollow and slides on the stem against the

pressure of a spiral spring. An indicator on the stem and a scale marked in fractions of an ounce on the handle serve to record the force existing. As long as the probe is following the bullet track, the pressure to propel it is conveyed through the medium of the spring, and this is recorded. As soon as the limits of the spring have been reached, as shown by the indicator, the danger-point has been reached and the probe must be partially withdrawn and its course changed. The stem of the instrument is insulated with a coating of rubber and has a connection by means of which it can be attached to a telephone receiver and used in connection with the Girdner apparatus (Fig. 164). As soon as the tip of the instrument comes in contact with the bullet, a distinct click is heard in the receiver.

In the **treatment** of gunshot wounds of the head the first care of the surgeon will be to bring about reaction, and in case of respiratory failure, to make **artificial respiration.** In the meanwhile the head is to be shaved and every aseptic preparation made. The scalp is to be turned back to expose the opening, the latter enlarged, splintered bone removed, hemorrhage arrested, and the dura examined. If the bullet lies on the latter, it is to be removed with the dressing forceps. If there is an opening in the dura, the bullet is to be sought for beneath this. The direction from which the shot was fired having been ascertained, the surgeon will be in a position to calculate the probable direction which the bullet track takes in the brain. If the bullet is located near

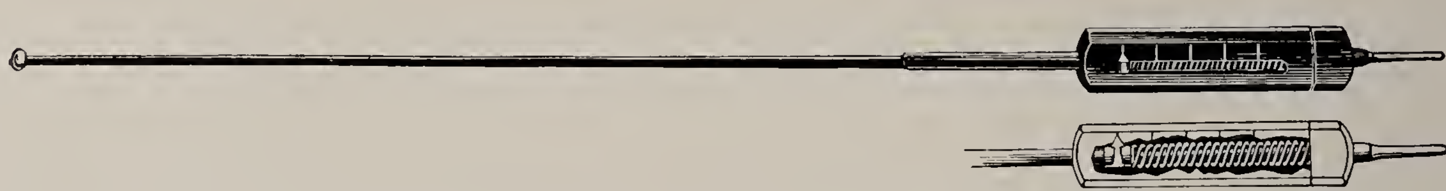


Fig. 243.—Graduated Pressure Bullet Probe for Brain.

the wound of entrance, it is to be removed with forceps. If located nearer the opposite side, a trephine counter-opening is to be made, and, with the probe held in position by an assistant, the surgeon may explore through the counter-opening, passing through the brain substance a fine steel needle with the sharp point ground off. When the proper direction is ascertained and the exact location of the bullet identified, it may be removed through an incision. It should always be borne in mind that the surgeon may do more harm by ill directed efforts to locate and remove the bullet than will probably result from the presence of the latter. Many surgeons are contented with clearing away the bone splinters and foreign debris at the wound of entrance and instituting tube drainage along the wound track. If the graduated pressure probe with telephonic attachment fails to locate the missile, the operative effort should terminate with the introduction of a soft-rubber drainage-tube and the dressing of the wound; further interference should be postponed until localizing symptoms arise. Bullets frequently become encysted and give rise to no further trouble.

NONTRAUMATIC INFLAMMATION OF THE CRANIAL BONES

Acute infectious osteomyelitis and tuberculous inflammation of the bones of the skull may both occur. The last named, though of infrequent occurrence, is not by any means so rare as the former. In tuberculous

inflammation of the cranial bones the application of the trephine in such a manner as to remove one or more buttons of bone, and in an area sufficient to include healthy bone as well, is preferable to curetment, in order to secure a permanent result.

Syphilitic caries and **syphilitic necrosis** of the skull are rather more frequent than tuberculous disease of the cranial bones. They occur in conjunction with the breaking down of a syphiloma or syphilitic gumma. The external coverings of the skull may ulcerate first, showing a necrotic external table, or the gumma may break down in the substance of the bone and reach the inner table. The latter condition is one of caries, and the former a necrosis, both of which may occur at the same site. Under an antisyphilitic regimen the smooth, white, external table of the skull, which appears at the bottom of the syphilitic ulcer, is gradually replaced by little islands of granulations which spring up from the underlying diploe and find their way to the surface of the outer table. Occasionally the bared portion of the outer table is lifted up *en masse* by the underlying granulations. In cranial bones bared by accident or in the course of plastic operative procedures the same process of repair occurs. This process, formerly known as **insensible exfoliation,** is now known to be result of the tendency of the granulations to dissolve the bone. Exfoliation of the entire thickness of the skull may also occur as a result of syphilitic necrosis, in which case pulsation of the brain may be recognized after separation or removal of the sequestrum.

Syphilitic osteoma results from a sclerosed condition of the bones of the skull in which the syphilitic deposit, instead of proceeding to suppuration and softening, pursues the opposite course.

Suppurative inflammation of the medullary substance of the bones of the skull occurs almost exclusively in connection with diseased conditions of the mastoid and will be described in connection with inflammations of the ear (see page 583).

The ridgelike prominences which are sometimes observed along the lines of the sutures and are easily felt by the fingers are due to **rachitic disease** of the cranial bones. Likewise the persistence of open fontanels is of rachitic origin, showing an irregularity in the development of the cranial bones which proliferate from the suture lines.

Craniotabes is a condition observed in rachitic children in which limited areas in the cranial bones undergo softening and absorption. Such spots yield under the pressure of the finger and feel like wet parchment. They occur most frequently over areas subjected to pressure, like the parietal and occipital regions, but they occasionally appear in the frontal bone. Rachitic softening of the periosteum also occurs, which on slight injury leads to extravasations of blood between the bone and the periosteum resembling a cephalhematoma of the newborn.

TUMORS OF THE CRANIAL BONES

Tumors of true congenital origin must be very rare, as none are on record. **Cephalhematoma,** however, resulting from prolonged pressure on the head during labor, is not uncommon. This differs from the so-called **caput succedaneum,** which, while of similar origin, consists of a general edematous swelling from venous stasis. Cephalhematoma, on the other hand, consists of

an extravasation of blood between the pericranium and the bone. Extravasation between the cranial bones and the dura mater has been found in the cadaver of the newborn, simultaneously with cephalhematoma. If the effused blood of a cephalhematoma is not resorbed in the course of a few weeks, the elevated periosteum proceeds to the formation of new plates of bone and a parchment-like crepitation is felt beneath the palpating finger. These bony plates may persist and finally inclose the fluid in a true cyst with bony walls.

The **treatment** of cephalhematoma in cases in which no perceptible diminution occurs under the use of evaporating lotions continued for a fortnight, consists in evacuating the contents by means of a puncture with a thin-bladed scalpel, under strict antiseptic precautions. The fluid will be found to be chocolate-colored and devoid of fibrinous clots. Aspiration of the fluid is also recommended. Finally, free incision may become necessary in order to effect a cure. Firm compression by means of semielastic bandages should follow either puncture or aspiration. A convenient pressure bandage may be made from ordinary domestic flannel, the strips being cut on the bias.

Fig. 244.—Sarcoma of the Orbit.

Cranial pneumatocele is a name given to a diffusion of air between the pericranium and the bone. The air finds its way into this abnormal position usually through some defect in the cancelli of the mastoid portion of the temporal bone. Owing to the fact that the air is filtered through cavities lined with mucous membrane, bacterial infection and inflammation do not necessarily follow. Acts of sneezing may be the exciting cause of the condition. By firm bandaging the air can sometimes be forced from its position, escaping through the Eustachian tube. Usually, however, recurrence takes place. Where, as sometimes occurs, the entire scalp becomes "ballooned," evacuation by means of the trocar may be necessary. The repeated injection of tincture of iodin has proved successful and should be tried.

Chondroma of the cranial bones is a very rare affection. Osteoma of the frontal sinuses is described elsewhere (see page 518). Syphilitic osteoma has been already discussed (see page 453).

Sarcoma of the cranial bones originates from the diploe. It usually proceeds toward the surface. Those sarcomatous growths which involve the dura generally have their origin there. The prognosis is very grave and extirpation is usually followed by recurrence. The orbit is frequently the seat of sarcoma (Fig. 244). The nasopharynx is also a favorite location, whence the growth may extend to the nasal fossa and into the pharynx, or perforate the base of the skull. Sarcomas arise in the mucoperiosteal structures in this locality. Their growth is accompanied by intense headache and sometimes by profuse epistaxis.

THE BRAIN

Contusions of the Brain.—These are the result of external violence transmitted from the skull to the brain, the skull itself being simultaneously injured. Direct injury without involvement of the skull takes place exceptionally at the apex of the orbital cavity; it is possible, however, for only very small objects to enter at this point without injury to the bone.

Sudden changes in the shape of the skull, the latter returning at once to its original shape, fractures, and other injuries of the bony capsule, may produce solutions of continuity of the brain tissue. Contusions are more frequently observed than incised or lacerated wounds, owing to the nonresisting character of the brain substance, which transmits the vulnerating force in all directions.

The extent of the damage inflicted will vary from merely punctate hemorrhages in one or more areas to the crushing of an entire lobe with pulpification of the brain substance in which fragments of bone may be embedded, and extensive hemorrhage. Or, extensive ruptures located in different areas of the brain (**multiple lacerations of the brain**) may be present. Contusions occur with the greatest frequency at the base; in spite of this the pons varolii, crura cerebri, and medulla oblongata often escape injury.

Contusions and lacerations of the brain follow a **course** corresponding to the extent of the damage inflicted. The symptoms may be transient, recovery taking place in a few days, or permanent lesions may result in more or less permanent impairment of function. Many weeks or even months may elapse before the paralyses and psychic disturbances disappear. In other cases abscesses of the brain may follow. In cases in which recovery has apparently taken place impairment of memory may exist, and psychic disturbances, epilepsy, etc., develop. Again, in the unfavorable cases the paralyses may be permanent, encephalitis and cerebral softening from fatty degeneration of the vessels finally destroying the patient.

Slight contusions of the surface may result in but little apparent disturbance of the functions of the brain. But grave symptoms may arise from severe contusions and lacerations. The latter, occurring at the base in the posterior fossa, are almost without exception immediately fatal on account of the important nervous centers essential to life that are involved in the injury. Slight contusions and lacerations occurring anteriorly may interfere simply with the functions of the optic and olfactory nerves. Disturbances of the motor oculi and abducens may also follow. One of the symptoms peculiar to laceration of the brain is the tendency of the patient to lie on the affected side, with the knees drawn up and the head and shoulders depressed. This peculiar position, in which nearly all of the flexors of the body take part, has never been satisfactorily explained.

After recovery from the immediate effects of contusion and laceration of the brain, certain symptoms of a more or less chronic character occur. These include paralysis of both motion and sensation in the upper and lower extremities. Other important symptoms are the following: **Amnesia,** or loss of memory; **aphasia,** or incoordination in speech; and **agraphia,** or inability to express language in writing (see Cerebral Localization, page 466).

Repair takes place through the medium of the connective-tissue elements

and vessels of the pia mater. Regeneration of nerve-cells, and probably of nerve-fibers, does not take place (Tschistowitsch). The process of repair may occupy weeks, or even several months. In cases which survive the immediate effects of the injury degenerative processes ("yellow softening") may occur, having but few or no symptoms at first and proving suddenly fatal at the last (**traumatic late apoplexy**).

Wounds of the Brain.—Wounds of the brain are to be distinguished, for purposes of study, from contusions of the brain, in that, in the former the lesions take place in conjunction with closed (simple) fractures and similar injuries, while in the latter the injury of its encasement is an open one, or one which effects a communication between the exterior surface and the brain. They may be classified as contused, punctured, and lacerated. Wounds of the brain may occur from force bluntly applied, from sharp objects, or from both coincidentally applied, as, for instance, when a blunt object produces a fracture of the skull, a splintered fragment causing a wound of the brain. Or, a sharp object may produce a contused wound of the brain, the outer bony structure neutralizing the force at the diploe and the splintering of the latter causing the brain injury.

If the patient survives the immediate effects of the injury (shock and hemorrhage) the future course of the case will depend more on the occurrence of infection than on all other circumstances combined. With the invasion of the traumatic area by pus microorganisms suppurative inflammation develops and **encephalomeningitis** results. This is usually progressive in character. Exceptionally, in cases in which opportunity for drainage is afforded through the existing wound, the infectious inflammatory process may remain localized and healing take place. Or, with the arrest of free escape of pus from the damaged area retention occurs and an abscess results (**acute traumatic cortical abscess**, Krönlein).

Intracranial Hemorrhage.—The predominating symptoms in cases of intracranial injuries are those arising from the escape of blood from the vessels.

Extradural Hemorrhage.—This may take place with or without fracture of the skull. It usually occurs from rupture of one of the branches of the middle meningeal artery, the blood escaping between the dura and the skull. Local compression of that part of the brain lying near the artery will be the first symptom, and diminution or loss of power on the opposite side of the body will follow. The most important feature is the occurrence of a well-marked interval of intelligence, after the first concussion, between the reception of the injury and the supervention of symptoms pointing to pressure on the brain substance, such as interference with motion or speech if the effusion of blood is opposite a portion of brain presiding over these; or hemiplegia, stupor, coma, and irregular and automatic movements. In addition to the above, there will be contraction of the pupils, followed in the later stages by dilatation. When the compression is local, the pupil may be dilated and immovable. In a right-handed person aphasic symptoms occur in injury of the left side. The pulse is slow and full at first, but becomes more rapid as compression increases. The breathing, at first quiet, becomes stertorous, and convulsions may occur. The hemorrhage may cease spontaneously, the dura, as it is crowded away from the skull by the effused blood, making pressure on the point of rupture. Mental

disturbances will persist, however, until the clot is resorbed, and traumatic (Jacksonian) epilepsy may result from the irritation arising from the presence of the scar.

Subdural and Subarachnoid Hemorrhage.—Bleeding in these situations is often combined, and when the hemorrhages occur separately it is impossible to differentiate them clinically. In most instances the arachnoid is torn and the effusion of blood takes place in both the subdural and the subarachnoid space. Exceptionally, a true subdural hemorrhage is caused by injury of one of the sinuses of the dura mater, or by a coincident rupture of the middle meningeal artery and dura just after the vessel enters the skull at the foramen spinosum. A true subarachnoid hemorrhage may follow rupture of the vessels of the pia mater without a tear in the arachnoid.

If the escape of blood from the injured vessel is rapid, and this is usually the case, symptoms of pressure appear quickly. The lucid interval so characteristic of extradural or subcranial hemorrhage is absent, the symptoms of concussion merging into those of compression. In the exceptional instances in which the hemorrhage takes place slowly, the cerebrospinal fluid is gradually displaced by the effused blood, and symptoms of disturbance of brain functions are delayed in their appearance. In subdural hemorrhage the blood tends to gravitate in the direction of the basal ganglia, and pressure in this locality gives rise to general compression, rather than to special symptoms, the respiratory center becoming involved early.

Intracerebral Hemorrhage.—Nevertheless, hemorrhage from the vessels of the pia takes place in cases of contusion and wounds of the brain. It is impossible to differentiate clinically this variety and the preceding except by operation.

Intraventricular Hemorrhage.—Hemorrhage into the lateral ventricles can take place only as the result of very extensive injuries; hence it is of rare occurrence. Coma sets in early and a rapidly fatal termination follows.

(For foreign bodies in the brain, see page 449.)

The Diagnosis of Brain Injuries.—This is based almost exclusively on the localized cerebral symptoms (Cerebral Localization, see page 466). Special difficulties in the interpretation of these are present, however, due to the following: (1) the manifestaton of concussion and compression masking the other symptoms; (2) the presence of multiple and differently located lesions; (3) complex symptoms resulting from extensive injuries combined with intrameningeal hemorrhages; (4) the presence of localized injuries which give rise to no topical symptoms; (5) the rapid supervention of infection with its accompanying symptoms (see Traumatic Meningitis; also Fractures of the Skull).

Traumatic Meningitis.—This is always the result of infection, most frequently from the presence of Streptococcus pyogenes and Staphylococcus pyogenes aureus (Macewen). Infection takes place almost exclusively from the external surface of the body. It may follow directly after the injury (early meningitis) or develop later (late meningitis). The first occurs in connection with the reception of the injury or in the course of the healing of the wound. The late form may appear weeks or even months afterward; its occurrence is favored by the presence of splinters of bone, foreign bodies, and other sources of irritation. The pia mater and arachnoid are more com-

monly involved (**leptomeningitis**); in these the spread of the infection is rapid. Traumatic inflammation of the dura is comparatively rare and is usually limited to the place of injury (see page 443).

Symptoms.—In cases of early meningitis the symptoms are usually masked by those of the injury, and in late cases it is difficult to distinguish them from those due to complicating inflammatory conditions, such as suppurative encephalitis, abscess of the brain, etc. In cases in which it is possible to separate the symptoms, these will include chills, fever, headache, nausea and vomiting, contracted pupils, restlessness followed by delirium, and stupor succeeded by coma.

Encephalitis is always an accompaniment of suppurative meningitis. Under these circumstances the inflammation follows the pia and affects only the superficial portion of the convolutions. The extensive character of the inflammation here contributes largely to the fatal result. In addition to cortical encephalitis there occurs a suppurative inflammation of the deeper portions of the brain, circumscribed in character, constituting **abscess of the brain** (see page 460).

Diagnosis of Meningitis and Encephalitis.—The occurrence of intracranial inflammation, particularly of a suppurative character, is accompanied by a sudden rise of temperature, and the onset of severe cephalalgia at or near the seat of injury. A chill may or may not precede the temperature elevation. In examination of the wound care should be taken to exclude erysipelas of the scalp and phlegmonous inflammation between the aponeurosis of the scalp and the pericranium, by ascertaining the presence or absence of the characteristic edematous swelling of the one, or the combined tenderness and swelling of the other, if, indeed, these have not preceded the intracranial inflammatory involvement. The symptoms of the one may overlap those of the other.

The next characteristic symptom is gradual loss of consciousness. This course marks a rapid involvement of the cerebral surface and the cortex of the hemispheres. Cases less rapid in their development show paralysis of the side opposite the injury and convulsive movements. When the dura is exposed through an opening in the skull, it has been suggested that increase of the pulsation of the brain is a sign of commencing intracranial inflammation. The accumulation of serum or pus, however, increasing the tension and forcing the dura against the edges of the opening, will *lessen* the visible pulsations. This latter symptom is not trustworthy, particularly in focal suppurative encephalitis (brain abscess), for the reason that the latter has been shown to be present in conjunction with pulsation; on the other hand, a number of conditions may exist, exclusive of brain abscess, which lead to absence of pulsations. The occurrence of convulsive movements of the ocular muscles indicates the existence of a basilar meningitis.

The **fever** of meningitis and encephalitis is usually of a continuous character; variations, if any occur, are not extreme. If repeated chills occur, or well-marked exacerbations of fever are observed, pyemia is indicated. Death may take place in twenty-four hours from the commencement of the attack or be postponed for several days.

Meningitis of traumatic origin and cortical encephalitis cannot clinically be separated from each other; hence, the symptoms in the above description have been grouped together.

Abscess of the brain is marked by a slow development, the symptoms pointing to disturbances of function of separate portions of the brain and localized headache. In the beginning the fever is not very decided, chills are absent, and morning remissions are the rule. Twitchings or convulsive movements in either the upper or the lower extremity of the opposite side may occur; peripheral paresis or paralysis of an entire extremity or of separate groups of muscles of the same side is observed (see Cerebral Localization, page 466). The symptoms are progressive in character until the suppurative focus enlarges sufficiently to reach the surface, when it either passes beyond the established boundary wall and infiltrates the surrounding brain tissue, or a violent septic meningitis sets in. In either case, death soon follows (see Abscess of the Brain, page 460). In differentiating meningitis and cortical encephalitis on the one hand, and abscess of the brain on the other, the time of the occurrence of the symptoms should be considered in their relation to the injury. An inflammation which occurs during the first week usually indicates the former; a later and gradual development, the symptoms being of the character above described, is indicative of the presence of cerebral abscess. Should the case be seen sufficiently early an exploratory operation is indicated in view of the hopelessness of this class of cases when purely expectant treatment is followed.

The **prognosis** of traumatic meningitis is always unfavorable and the **treatment** in the main unsatisfactory, owing to the opportunities offered for the spread of the infection on account of the anatomic structure of the pia mater, its extensive ramifications and the rigid bony encasement of the inflamed parts and consequent early pressure on vital organs. The efforts of the surgeon will be directed mainly to its prevention by the exercise of a most thorough and rigid aseptic régime in connection with all cases of compound fracture of the skull or wound of its coverings. With the first sign of infection the wound should be opened up freely and the surrounding tissues drained. If meningitis develops, prompt measures must be taken to limit the infectious process by giving exit to pent up secretions, removing blood-clots, and instituting drainage. To accomplish this the opening in the skull must be enlarged if necessary, and the dura incised to expose the pia mater as much as possible.

Hernia Cerebri (Acquired Encephalocele).—By this is meant the escape or protrusion of brain substance from the cavity of the skull. It occurs most frequently in connection with gunshot wounds and compound fractures with loss of bony tissue. It may follow extensive operative attacks on the skull (craniectomy, etc.). The immediate and instantaneous occurrence of gaping of a simple fissure may permit brain substance to escape when this takes place in connection with a tear in the dura mater. Syphilitic caries and necrosis rarely give rise to it.

Hernia cerebri may be primary or secondary. In the primary cases the brain substance may pour out at once. It is usually accompanied by a flow of cerebrospinal fluid, which may continue for several hours. In cases of secondary hernia cerebri the protrusion may occur in the first week following the injury or it may be delayed for several weeks (cerebral prolapse). Here the portion of brain not separated at the time of injury is gradually protruded from the opening in the dura and skull. The cause of the protrusion is an abnormally high intracranial pressure due to the inflammatory processes and

their products (exudates, pus, etc.). In cerebral prolapse the protruding mass slowly increases in size until it attains the size of a walnut or is even larger. Distinct pulsation is usually present. The mass soon loses the normal appearance of the brain surface, if this has not been destroyed at the time of the injury, and becomes dark or black and softened and necrotic.

The **diagnosis** may be usually made on the gross appearances. In case of doubt microscopic examination should be made. Extensive granulations due to ulceration of the surface of the brain may cause a fungous and bleeding mass (**hemorrhagic granuloma**) to protrude from the wound and simulate hernia cerebri (*vide infra*).

The **prognosis** will depend on the amount of brain substance extruded, the importance of function of the part lost, and, above all, the occurrence or non-occurrence of infection. Death usually takes place from septic encephalomeningitis, a cerebral abscess developing behind the protrusion. In the absence of infection the mass is cast off, the remaining portion shrinking until it disappears in the cranial cavity.

Treatment.—Shaving off the prolapsed mass with or without subsequent cauterization is recommended. Attempts to cover in the prolapsed mass by a plastic procedure, consisting of transplanting a flap attached by a pedicle, have succeeded (Adams, Kocher).

Hemorrhagic Granuloma.—This is also due to infection arising usually from the presence of splinters, foreign bodies, or other sources of irritation occurring in an open wound of the skull. The granulations spring from an ulcerated area on the surface of the brain. The protruding mass may be the size of a walnut or larger. It is soft, pulsating, bends readily, and may contain small suppurating foci. Microscopic examination may be necessary to distinguish it from hernia cerebri (*vide supra*). Its removal, together with splinters of bone, foreign body, or necrotic tissue that may be present, is usually followed by cure.

Abscess of the Brain.—Abscess of the brain arises from (1) traumatism (traumatic abscess of the brain); (2) disease of the ear (otitic brain abscess); (3) infections from the nasal cavity; (4) infectious processes on the skull (osteitis, caries, etc.); (5) metastasis from a distance (metastatic brain abscess).

Traumatic abscess may be divided into the acute and chronic forms. The acute form is due to an open injury of the skull, usually a depressed fracture with injury of the brain. The pia mater is also more or less infected, as a rule (leptomeningitis, see page 458). The latter, if it assumes the diffuse purulent form, will usually prove rapidly fatal. In more favorable cases the infectious process is limited to the seat of injury. The wound of the scalp presents the characteristic appearances of infection, and the usual constitutional manifestations of sepsis are present.

Treatment.—Removal of depressed portions or splinters of bone, foreign bodies, such as hair, pieces of the vulnerating object, etc., and thorough disinfection of the surroundings (see page 432), should not be overlooked in the prophylaxis. Efficient drainage should be provided for. The simple lifting up of a neglected depressed fragment which has prevented the escape of pus has saved many lives after infection had occurred. Even with traumatic meningitis present (see page 457) the case is not necessarily hopeless. The removal of infected diploe, exposure and incision of the pia mater, with the

evacuation of purulent material and thorough drainage, may save the patient.

Chronic Traumatic Abscess of the Brain.—The chronic form may follow the acute as a result of the extension of the infection in this direction. An acute abscess lasting for from three to five weeks may be said to have become chronic. The pus cavity is usually seated in the medullary substance and tends to point either toward the surface through the cortex or, in the case of abscess of the frontal and parietal lobe, toward the lateral ventricle. In the case of abscesses which tend to perforate the cortex, the presence of adhesions at the site of the original injury and infection may prevent purulent extravasation beneath the pia mater. The lodgment of foreign bodies carrying infection into the brain substance is the usual cause of their occurrence. Brain abscess which occurs at points comparatively remote from the original point of infection, with intervening normal brain tissue, are probably due to thrombophlebitis of a sinus.

A chronic abscess is usually lined with a yellowish-white capsule, made up of a layer of connective tissue (the pyogenic membrane of the older writers), and may remain encapsulated for a considerable time, this sometimes extending over a period of months, or even years, and involving a whole lobe or even an entire hemisphere without producing definite symptoms; extension of infection usually takes place, however, each step in its progress being marked by a fresh attack of encephalitis and the formation of new and adjacent foci. Exceptionally, in favorable cases these become included in the original cavity. In the absence of a well-defined capsule a rapid increase in the size of the abscess takes place; this, occurring in the direction of the cortex and before adhesions form at the site of the pia mater, leads to diffuse and rapidly fatal meningitis. From three to six weeks are required for the development of the capsule.

Symptoms.—In chronic traumatic abscess of the brain the primary cerebral symptoms vary in different cases from those apparently due to concussion to well-defined focalized manifestations according to the site of injury. In a typic case these subside, and the patient apparently recovers. The latent period which follows may be marked by exacerbations of fever, some confusion of thought, mental irritability, irrational acts, headache, and dizziness. After the latent period the secondary symptoms appear. These also vary greatly. There is usually fever, though this is not a pathognomonic symptom, since it may occur in diffuse meningitis. The occurrence of a chill is not a constant symptom. The headache, which is referred to the injured region, usually becomes intensified, particularly in certain movements of the body. Neuralgic pains in the distribution of the fifth nerve are present, as a rule, and constitute a very suggestive symptom in this connection. Increase of the symptoms is due to variations in cerebral pressure, and increase of fever is coincident with extension of infection and the occurrence of fresh suppuration. The symptoms subside and reappear until the so-called **terminal stage** is ushered in. With the advent of this extension cerebral edema occurs, and death takes place from this cause or from rupture into a ventricle.

Diagnosis.—This must rest largely on the history of apparent recovery from the injury, the intervening latent or semilatent period, the supervention

of the secondary symptoms, and, finally and chiefly, the localizing manifestations (see page 466, Cerebral Localization). The appearance of pus flowing from a fissure, or from between two fragments, in cases in which the wound remains unhealed, together with a septic condition of the latter, will demand investigation. Pyemia is to be excluded if chills are absent or infrequent and atypic, and if there are no other manifestations of this condition present, as joint involvement, etc.

Treatment.—The invariably fatal termination to which chronic traumatic abscess of the brain leads, unless evacuated, imperatively demands operative interference. In doubtful cases presenting evidences of a grave intracranial condition, it is better to make an exploratory investigation than to defer interference until there is but slight or no hope of the patient's recovery. Drainage must be obtained at all hazards. This may follow on the removal of a fragment of bone. If evidence of pus is not obtained by this procedure, or its escape is not deemed sufficiently free, the opening in the skull is to be enlarged. The dura must be incised if this is tense, or pressed outward, or if pulsation is absent. The dura may be discolored or gangrenous in appearance. If these signs are not found, and if there are no evidences of an abscess on opening the dura, the cerebral tissue itself should be thoroughly explored.

Otitic Cerebral Abscess.—Abscesses of otitic origin follow chronic otitic suppuration in the vast majority of cases. The infectious process usually has its origin in caries of the attic, the suppuration extending thence through the roof of the tympanic cavity. Or, the suppurative process may spread to the mastoid antrum. In the latter case the pus accumulates in the mastoid cells, with possible perforation of the outer bony layer, or an extradural abscess may form from infection of the lateral sinus. The suppuration may extend beneath the tentorium and form a *cerebellar abscess*. With symptoms of mastoiditis present in a case of abscess of the brain of otitic origin, therefore, either an extradural abscess from infection of the lateral sinus or a cerebellar abscess exists. In the absence of mastoiditis the suppuration focus is most likely to be found in the temporal region. Both conditions may coexist, however.

Diagnosis.—The signs of intracranial suppuration (remittent temperature variations and increased intracranial pressure) are present in otitic abscess, whether situated in the cerebrum or the cerebellum. In suppurative mastoiditis with intracranial complication the attacks of fever are intermittent and of short duration and the period of freedom longer. Intracranial suppuration gives rise to headache and vomiting from increased and varying intracranial pressure. The headache is subject to evening exacerbations, with rise in the temperature. It may be increased by percussion on the affected side. An attack of vomiting may be produced by a sudden change in the position of the patient. Choked disc, also due to the latter, is present, and is a valuable diagnostic sign. Distinctly focalizing symptoms are absent in the great majority of cases.

Treatment.—The abscess cavity must be evacuated and drained. In the case of abscess in the temporal lobe, this may be reached through the antrum and tympanic cavity (Schwartze and Stacke). Or, the suprameatal fossa and squamous portion of the temporal bone may be exposed by turning

up a flap between the middle and the posterior vertical line of Krönlein (Fig. 245). These lines of incision are joined by a third commencing at the top of the tragus and crossing above the pinna. A rectangular opening is made in the bone corresponding to the exposed area. This opening, extended anteriorly, will expose the neighborhood of the Gasserian ganglion; if extended backward, the groove for the transverse sinus can be reached. It will also permit exploration of the usual site of otitic cerebellar abscesses.

The opening in the abscess, if such already exists, is to be dilated bluntly and a drainage-tube introduced. Drainage should be maintained long enough to insure complete emptying. If cerebral prolapse occurs, this is due either to a reaccumulation of pus, or to a collection of cerebrospinal fluid in an adjacent ventricle. In case of the latter lumbar puncture is recommended (Krönlein).

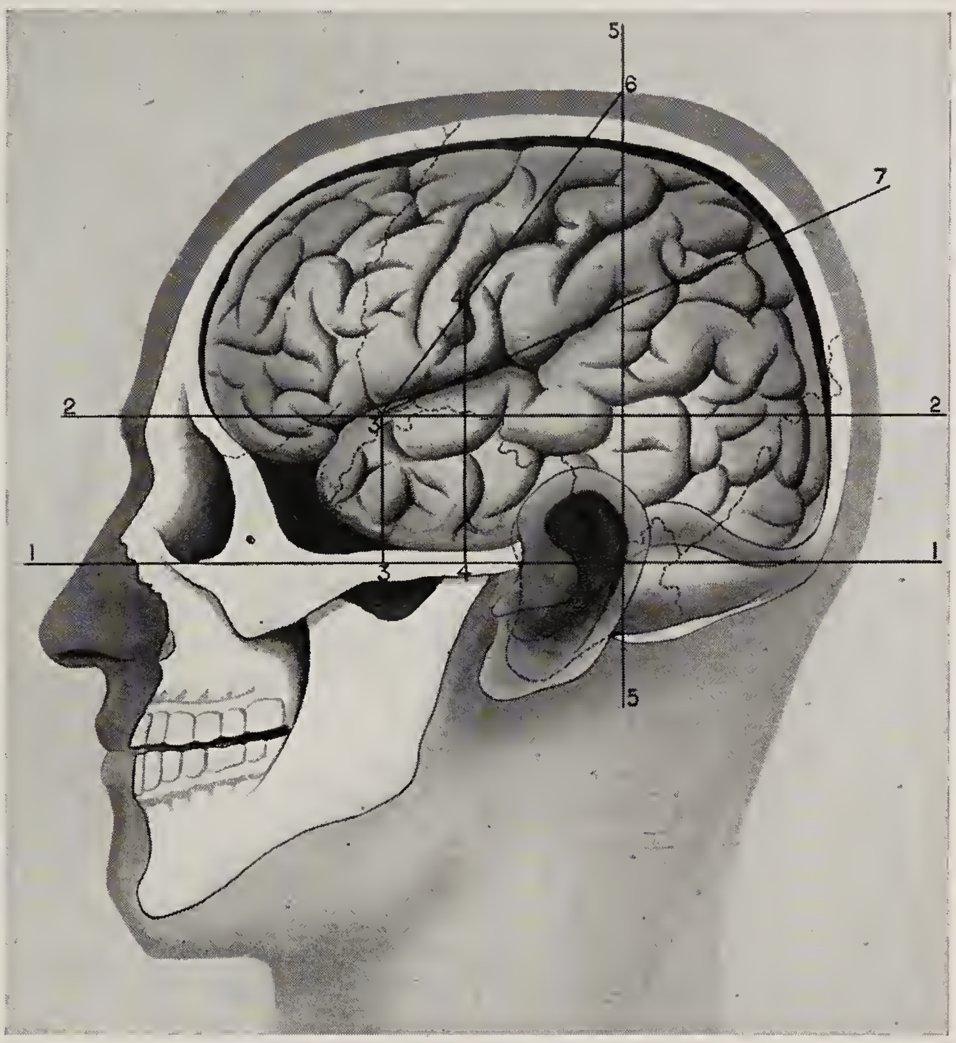


FIG. 245.—KRÖNLEIN'S CRANIOCEREBRAL TOPOGRAPHIC LINES.

1, 1, Base line, passing through the infraorbital ridge and the superior border of the auditory meatus; 2, 2, superior horizontal line, passing through the supraorbital ridge parallel to the base line; 3, 3, anterior vertical line, passing from the middle of the zygomatic arch perpendicular to the base line; 4, 4, middle vertical line, passing from the head of the inferior maxilla (immediately in front of the tragus) perpendicular to the base line; 5, 5, posterior vertical line, passing from the posterior palpable margin of the mastoid process perpendicular to the base line; 3, 6, line of fissure of Rolando (see p. 467); 3, 7, line of fissure of Sylvius.

Cerebral Abscess of Nasal Origin.—This is caused by suppuration in the upper nasal spaces and their accessory cavities. The infection may reach the brain by perforating the walls of either the frontal, the sphenoidal, or the maxillary sinus, or from the ethmoid cells, or it may follow the vessels (thrombophlebitis). The collection of pus may be extradural, or a true abscess of the brain may be present. Thrombosis of the cavernous sinus or leptomeningitis may occur. Rarely, the temporal lobe is involved.

Symptoms.—These are weariness, restlessness, headache, mental apathy, and vomiting. Choked disc is present. Focalizing symptoms are absent except in cases of large abscess producing pressure on the motor centers.

Treatment.—The frontal sinus should be opened, its posterior wall removed, if this has not been already destroyed, the dura opened if necessary, and the frontal lobe explored. Tube drainage should be employed.

Cerebral Abscess Developing from Disease of the Skull.—Cerebral abscess may arise from osteomyelitis or caries of the bones of the skull, of traumatic, tuberculous, or syphilitic origin.

Metastatic Cerebral Abscesses.—These arise most frequently from infected emboli originating in intrathoracic suppurative disease (gangrene of the lung, old empyema, etc.). The emboli follow the most direct route from the aorta, namely, through the left carotid and one or more of its terminal branches, finally lodging in the fossa of Sylvius. They are usually multiple, and the prognosis is, therefore, unfavorable. They may be simple, however, and hence efforts at operative relief are not excluded.

Infectious Sinus Thrombosis.—This may arise from any infectious inflammation of the soft parts of the head and face (erysipelas, anthrax, etc.); from severe infections of the adjacent cavities (oral, buccal, nasal, or pharyngeal); or from infectious processes in the bones (caries of the temporal bone from ear disease, periostitis of the jaw from a carious tooth, etc.). Its most common origin is in a suppurative mastoiditis following disease of the ear. In this connection it occurs with greatest frequency on the right side, is most commonly observed in male subjects, and is practically limited to the middle period of life. It usually develops by continuity to the wall of the sinus and there is a resulting thrombophlebitis of the latter. It may, however, extend from a thrombophlebitis of a vein in the primary focus. When extending directly to the sinus from disease of the mastoid, the inflammatory process as it reaches the sigmoid fossa invades the sigmoid sinus, whence the infection spreads, extending in many cases to the lateral sinus and sometimes to the internal jugular vein, or even to the superior vena cava. The thrombus breaks down and a purulent collection takes place within the sinus. More or less widely scattered embolic infection from attached fragments of the thrombus is the rule (see Pyemia, page 184). Metastatic abscesses may occur in the brain.

When thrombosis of the two petrosal sinuses is present, this usually coexists with the sigmoid affection. The disease as it attacks the cavernous sinus is generally bilateral.

Symptoms.—The symptomatology of infectious sinus phlebitis is that of pyemic infection, plus disturbances of brain function (see page 466, Cerebral Localization). Headache is an early and important symptom. Dizziness and vomiting are present. The fever is usually intermittent. The temperature, however, may sink to the normal or may even fall below it. Edema in and about the mastoid region, and tenderness over the jugular vein, together with the presence of a hard cord, are diagnostic in cases originating in mastoiditis. Pressure on the nerves which accompany the sigmoid sinus through the foramen (pneumogastric, spinal accessory, and glossopharyngeal) may occur and cause symptoms of compression and paralysis.

Repeated chills usher in the pyemic condition in the course of two or three days. The latter is marked by the occurrence of pulmonary complications (abscess and gangrene of the lungs). Such small emboli as pass the larger pulmonary capillaries lodge in the other organs (liver, spleen, kidneys, joints, sheaths of tendons. etc.) and cause characteristic symptoms, the most striking of which is jaundice, which develops coincidentally with enlargement and tenderness of the liver. Septic endocarditis may occur as a complication.

Thrombosis of the **petrosal sinuses** causes no special local symptoms. Thrombosis of the **longitudinal sinus** may cause edema of the scalp and dilatation of the superficial veins. Thrombosis of the **cavernous** and **trans-**

verse sinuses may cause exophthalmia from retrobulbar edema, and edema of the upper lid. Nerve pressure will cause neuralgia in the ophthalmic division of the trigeminus; isolated paralyses of the eye muscles give rise to abnormal positions of the globe and contracted pupils and ptosis. Total ophthalmoplegia may be present. Amaurosis may result from optic nerve pressure.

Diagnosis.—This depends on the local and general symptoms combined. The disease is most likely to be mistaken for typhoid fever, malaria, and miliary tuberculosis. Septic endocarditis occurring independently, and the presence of a cerebral abscess, may complicate the diagnosis. The history of a recent aural suppuration, and the presence of mastoiditis followed by edema, infiltration, or subperitoneal pus formation in the neighborhood of the mastoid, and later by tenderness and thickening in the course of the jugular vein on the corresponding side, serve to distinguish the affection as it exists in the sigmoid sinus. Edema of the eyelid and within the orbit and symptoms of nerve pressure in this neighborhood point to involvement of either the cavernous or the transverse sinus, or of both.

The **prognosis** in cases of even moderate severity of infection is unfavorable, in the absence of operative treatment. Early diagnosis and prompt operative interference govern the outlook for recovery more than all other considerations combined.

Treatment.—Prophylaxis demands the careful treatment of cases of aural suppuration, early opening of the mastoid in doubtful cases, and the antiseptic treatment of all infections within the area from which they can be transmitted to the cranial cavity. Infection of the sigmoid sinus demands the following: (1) Opening of the mastoid and thorough removal of the primary focus. (2) Exposure of the sinus and its exploration by puncture. If fluid blood fails to follow the puncture, the sinus is thrombosed. (3) Evacuation of the sinus through a half-inch vertical incision and the removal of the clot with forceps or a small sharp spoon to an extent sufficient to insure disintegration of the remainder and efficient drainage. If the upper two-thirds of the sinus can be evacuated and efficiently drained, this may be deemed sufficient. (4) If a decomposed thrombus extends below the opening in the sinus, drainage must be obtained at a lower point and the jugular vein ligated in a healthy portion of the vessel low down in the neck and excised. If the vein is palpably affected, preliminary excision is indicated, both for prophylactic and aseptic reason. In ligating the vein the procedure is similar to that for ligation of the carotid artery (see page 632). The vein should be ligated in two places and excised for its entire length between the ligatures.

Intracranial Tumors.—Of the intracranial tumors most frequently observed, 23 per cent are tuberculous growths, 13 per cent gliomas, 13 per cent sarcomas, 5 per cent hydatids, 4.6 per cent cysts, 4 per cent carcinomas, 3.6 per cent gummas, 2.2 per cent gliosarcomas, and 2 per cent myxosarcomas.* Of these, tuberculous growths are most frequent in early life, while the malignant forms are more common from the twentieth to the fortieth year.

As a rule, to which, however, there are exceptions, tumors of a malignant

*These figures are taken from White and Bernhardt's statistics as tabulated by Sêguin and Weir ("American Text-Book of Surgery").

character, as well as tuberculous lesions, tend to infiltrate the surrounding tissues. Benign growths are either inclosed in a well-defined capsule, as, for instance, in the case of cysts, or have distinct boundaries which separate them from the neighboring structures.

Only those tumors of the brain which possess a surgical interest will be considered in this connection. The inquiry will be limited, therefore, to those situated in the motor area and the adjacent regions (central convolutions). Less than 25 per cent of brain tumors are accessible to operative interference (Oppenheim).

Symptoms of Tumors of the Brain.—The clinical symptoms of those tumors included in the present study will comprise the following: (1) general brain symptoms or those caused by compression of the brain; (2) local symptoms. Of the general symptoms, the most important, on account of its frequency, is headache. It occurs early, is constant and severe, and is migrainelike in its dull and boring character. It is likely to be accompanied by nausea and vomiting. When the tumor is superficially situated, the headache may correspond to the site of the growth; generally, however, it is diffused. The next most important general symptom in this connection is **vomiting.** This usually occurs without effort and from an empty stomach (**meningeal** or **cerebral vomiting**). Finally, choked disc, or stasis of the visible veins in the fundus of the eye, when present, is of the greatest importance. it is absent, however, in a bout 40 per cent of cases of tumor in and about the central fissure. It may be due to obstruction in the circulation caused by increased tension of the cerebrospinal fluid, or it may arise from direct pressure on large venous trunks. When unilateral the tumor, as a rule, is situated in the opposite hemisphere. Usually, however, it is bilateral. It does not interfere with vision until secondary changes in the optic nerve take place.

Of the local symptoms, **localized convulsions** are of the first importance, particularly when these have been preceded by disturbances of sensibility or of muscular sense. The convulsions are at first tonic, then clonic in character, and usually begin in some definite group of muscles. As a rule, they follow a fixed sequence in the manner of their extension (see page 468, monospasm). The occurrence of **unconsciousness** is marked in proportion to the severity, extent, and length of the convulsive seizures and the frequency of their recurrence. Finally, the **paralyses** which eventually follow, while but temporary at first, soon become permanent (see page 468, monoplegia), and the spasms of the affected muscles cease except for the occurrence of slight twitchings during the seizure.

CEREBRAL LOCALIZATION

In this connection the symptoms arising from interference with the functions of the cerebral organs, either from injury or from tumor formation, will be considered. It is obvious that these symptoms can be of service only when the lesion occurs in a part of the brain the physiology of which is known. In the surgical sense the most important region of the brain is that known as the motor area. This includes the central portion of both central convolutions, the paracentral lobule, the operculum, and the foot of the third frontal convolution. The fissure of Rolando, from its proximity to this area, serves as a guide to the surgeon for the location of those portions of the area whose func-

tions have been demonstrated to exist. These are as follows: (1) the motor center for the leg; (2) the motor center for the arm; (3) the motor center for the head (Fig. 246). In all probability these regions are also the seat of cutaneous sensibility and of muscular sense.

Fig. 246.—Motor and Sensory Centers of the Brain.

The Fissure of Rolando. — According to Thane, this fissure commences at a point 55.7 per cent of the distance between the glabella and the inion, measured on the median line. It runs downward and forward at an angle of about 67 degrees, with an average length of $3\frac{3}{4}$ inches. The following is a ready method of locating the fissure (Fig. 247): (1) Draw a line from the glabella to the inion with an anilin pencil, and mark a point half an inch behind the midway point of this line; this represents the commencement of the fissure; (2) select a piece of stiff paper or light cardboard 4 inches square, fold it diagonally on the line AC, bringing the edge AD to correspond with the line AC; (3) place the card with the point A at the commencement of the fissure, and the edge AB on the middle line, when the folded edge AE will mark the site of the fissure sufficiently near for all practical purposes (Chiene).

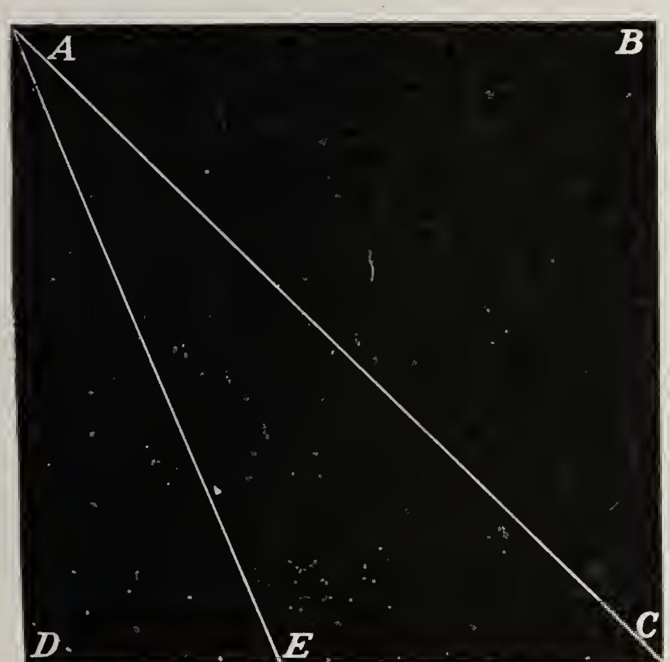


Fig. 247.—Chiene's Device for Locating the Fissure of Rolando (Reduced Size).

Lesions of the Motor Area.—It is impossible in any given case to exclude participation of the medullary substance in injuries of the cortical area. Further, cortical lesions may be so slight or involve so unimportant a focus as to give rise to no focalizing symptoms; on the other hand, these may be so extensive as to cause total destruction of both central convolutions. Finally, as more frequently happens, there may be partial destruction of both central convolutions, in which case the focalizing symptoms are both definitely expressed and characteristic. The most important of these are monospasm and monoplegia.

Monospasm, or convulsive movements limited to a single group of muscles, is a symptom of value in the diagnosis of lesions of the motor area. These movements are caused by mechanic irritation arising from the presence of foreign bodies, tumors, etc. They are at first tonic and then clonic. The convulsion always begins in that group of muscles in whose center the irritation occurs. In the case of a tumor, extension of the convulsive movements, corresponding to the area involved, takes place with its growth. The convulsion may affect first the face, then the finger, hand, arm, leg, foot, and toes; or in the reverse order (**Jacksonian epilepsy**). The convulsions are succeeded by permanent monoplegia, later by combined monoplegia; finally, with destruction of the motor centers, complete hemiplegia develops and the convulsions cease. Contractures occur (combined paralysis and rigidity) in the groups of muscles, the former seat of the convulsions, together with pain, paresthesia, and dulled sensation from involvement of the sensory area. This transition from monospasm into localized paralysis constitutes a most important diagnostic sign. The monospasm alone may be due to pressure on the motor area by a lesion situated in one of the neighboring lobes, either the frontal, the parietal, or the temporal. In the case of a subcortical tumor the effect is the same.

Monoplegia, or paralysis of a single limb, may occur as a pure symptom, or the paralysis may affect the upper and lower extremity simultaneously. The interposition of the arm center prevents simultaneous occurrence of symptoms referable to the leg and head centers without involvement of the former. A pure monoplegia is most frequently observed in connection with lesions of that portion of the leg center represented by the upper third of the anterior central convolution and the paracentral lobule. In the case of monoplegia of the arm the lesions have been found in the cortex of the middle third of the central convolution and in the adjacent sulci. Lesions of the leg and arm centers are the favorite starting-point for Jacksonian epilepsy.

Lesions of the Parietal Lobes.—These do not give rise to distinctly focalizing symptoms for the reason that the functions of this part of the brain are but little known. When on the left side and partly on the angular gyrus, optic and sensory aphasia, with disturbances of reading (alexia, or word blindness), probably caused by the interruption of connecting tracts between the visual center in the occipital lobe and the speech center in the left temporal lobe, have been observed. Muscular sense may also be interfered with. Remote effects of tumor pressure on neighboring centers (motor area, sensory area of the cortex, posterior section of the internal capsule, and the occipital lobe) will cause corresponding focalizing symptoms.

The **frontal lobes** are the seat of the mentality. Lesions of these are followed by weakness of memory, apathy, and similar aberrations of the mental state.

An ataxic gait may be present (L. Bruns's frontal ataxia), with weakness or paresis of the trunk muscles. These are due to a lesion of the trunk center in posterior portions of the first frontal convolution. Encroachment on the motor area by the growth of a tumor will cause temporary monospasm and monoplegia, and growth in the direction of the base causes symptoms of loss of smell (**anosmia**), disturbances of vision, optic nerve atrophy, exophthalmos, etc. Choked disc is a later manifestation. Hysteric convulsions or genuine

epilepsy may develop. Finally, there may be turning of the head and eyes toward the opposite side. The presence of **motor aphasia** in a right-handed person indicates that the lesion is situated in the **speech region.** This consists of the posterior half of the third (Broca's) convolution, the island of Reil, and the first temporal convolution, including the cortex of the fissure of Sylvius. The same symptoms occurring in a left-handed person show the lesion to be similarly situated on the right side. Halting speech (**bradyphasia**) and fruitless whispering efforts (toneless motions of the lips) are characteristic symptoms. To these may be added inability to write correctly (**agraphia**) and word deafness or the inability to understand spoken words (**sensory aphasia**). Motor aphasia and sensory aphasia may be combined. An absence of aphasic symptoms, however, does not necessarily exclude lesion on the left side. On the other hand, aphasia may be an accompaniment of a lesion in the motor area.

The Occipital Lobe.—Lesions of this region are always accompanied by symptoms referable to disturbances of the visual center situated in the cortex of the calcarine fissure of the median surface of the occipital lobe. The most important of these is that which causes the loss of the power of vision of the lateral half of the visual field of each eye (**hemianopia**). Though the focal lesion may occupy but one side, both eyes are affected. The inner (nasal) half of one visual field and the outer (temporal) half of the other visual field are affected (**homonymous hemianopia**). Hallucinations of vision and flashes before the eyes are present. Optic aphasia and alexia may result from tumors seated in the medullary portion of the left occipital lobe, causing disturbances of the association tracts between the visual center and the speech center.

Tumors of the **corpus callosum** are rare and present but few general symptoms. In cases of close approximation or growth into the central convolution there may be primary paraparesis. Grave intellectual disturbances may be due to interruption of important association tracts.

The **center of hearing** is situated in the upper convolution of the temporal lobe, the center of each side serving for both ears. Lesions in this region give rise to temporary disturbances of hearing. Only lesions of both sides give rise to permanent deafness. Irritations of one center give rise to buzzing, rumbling, and ringing sounds in the opposite ear.

The **sense of smell** is probably situated in the uncinate gyrus. Hallucinations of smell have been observed in connection with lesions in this region.

Lesions of the central ganglia (corpus striatum and optic thalamus) occur without symptoms of localized disease unless the internal capsule is affected, when disturbances of the fibers of the pyramidal tract are present, giving rise to hemichorea, hemiathetosis, tremor, contralateral convulsions, monoplegia, and hemiplegia. In lesions of the posterior region of the internal capsule hemianesthesia is present. Lesions of the posterior section of the optic thalamus cause hemianopia.

Corpora Quadrigemina.—Tumors in this region cause disturbances of pupil reaction and the motility of the globe by interfering with the function of the oculomotor or third nerve. These are not usually symmetric nor of equal severity. As a rule, the abducens escapes; it may, however, give the first symptoms. Later there occur ataxic symptoms, with incoordination in standing and walking, and of the movements of the arm. Tremor of the extremities

on the opposite side have been noted. These symptoms are also present in tumors of the pineal gland, but the trochlear and abducens paresis is more marked.

Tumors of the Pons.—A pons symptom usually deemed characteristic is conjugate paralysis of the lateral recti of the eye. The external rectus of one side and the internal rectus of the other are involved. As a result the patient cannot move the eyes beyond the median line toward the side where the tumor is situated. Owing to the close proximity of the tracts for both sides of the body, bilateral manifestations, both motor and sensory, are easily produced; alternating and combined paralyses of the facial, abducens, or trigeminus nerve on the side of the tumor, and paralysis of the extremities on the opposite side of the body may be present. Paralysis of the recti of both sides (bilateral conjugate paralysis) occurs. The eyes cannot be moved to the right or left, though convergent and upward and downward movements remain unaffected. There is paresis of the facial, abducens, and trigeminus nerves, and paraplegia of the extremities; anesthesia, ataxia, tremor, and disturbances of speech, mastication, and deglutition are present. When the growth is toward the base, pressure on the auditory nerve causes disturbances of hearing. When in an upward direction, it causes cerebellar symptoms; and when backward, symptoms arising from the medulla oblongata.

Medulla Oblongata.—Opportunities for the observation of bulbar manifestations of focal injuries are not frequent; with the involvement of the respiratory and circulatory centers these lesions prove rapidly fatal. Tumors of this region are followed by paralysis in the area of distribution of the glossopharyngeal, pneumogastric, spinal accessory, and hypoglossal nerves. Paralysis of the pharynx and velum, disturbances of deglutition and speech, aphonia, slow pulse, followed later on by rapid pulse, Cheyne-Stokes respirations, and paresis and atrophy of the tongue, together with vomiting, all go to make up a characteristic clinical picture. Most of the symptoms are bilateral. Death often takes place suddenly. Cases occur in which all symptoms are absent for a considerable time. This is specially true of cysts and obstructions in the aquaeductus Sylvii with resulting accumulation of fluid in the fourth ventricle (**internal hydrocephalus**). With the occurrence of the latter, marked symptoms of brain pressure supervene. Diabetes mellitus is sometimes present. Convulsions of a hysteric character are frequently observed. Choked disc is rare.

Lesions of the Base.—The symptoms arising from lesions at the base vary according to their location. Those in the anterior fossa cause unilateral loss of the sense of smell (**anosmia**), unilateral amblyopia, atrophy of the optic nerve on the same side, and paresthesia in the first branch of the trigeminal. Symptoms arising from pressure on the frontal lobe or involvement of it follow extension of the growth of a tumor. This, occurring on the left side, leads to disturbances of speech. Lesions of the middle fossa, particularly those medianly situated (optic chiasm, sella turcica, and hypophysis cerebri), give rise to the most striking symptoms.

Here arise characteristic and typic visual disturbances. Dimness of vision (**amblyopia**), with blindness of the external half of the visual field (**temporal hemianopia**), and, later, atrophy of the optic nerve with amaurosis; paralysis of the muscles of the eye, particularly of the oculomotor, followed by ptosis;

diabetes mellitus, polydipsia, and polyuria are sometimes present. Hypertrophic disturbances of the hypophysis are followed by enormous increase in size of different portions of the body, particularly in the facial region, and hands and feet (**acromegaly**). Tumors laterally situated produce pressure on the fifth nerve and Gasserian ganglion, with extremely severe neuralgia in all of the branches, and paresthesia. Neuropathic keratitis occurs, weakness and atrophy of the muscles of mastication are present. The tumor may increase sufficiently in size to cause symptoms in the frontal and temporal lobes and in the crus cerebri. Choked disc is sometimes present. Lesions of the posterior fossa cause symptoms referable to important nerve-trunks (fifth to twelfth), the pons, and the medulla oblongata. In the case of neoplasms the symptoms are first unilateral and then bilateral. It is almost impossible to differentiate new growths situated at the base from those of the cerebellum and crus cerebri.

Tumors springing from the dura mater, pia mater, and osseous structures at the base are accompanied by intense pain and by a tendency to perforate externally. Aneurisms of the internal carotid, basilar, median, and posterior cerebral arteries give rise to basilar symptoms. A bruit, synchronous with the pulse, may sometimes be obtained on auscultation in cases of aneurisms and highly vascular tumors.

Neoplasms superficially situated (those originating in the cortex, meninges, or bones of the skull), with their tendency to grow externally, give rise to thinning of the adjacent bone by erosion or osteoporosis. Percussion may cause pain in a circumscribed area and elicit a tympanitic note and cracked pot sound. In the thin skulls of children and the aged these symptoms are without value. With advance in the growth of the tumor and continued erosion of the skull, perforation of the latter finally takes place externally, causing local edema of the scalp and sometimes the appearance of a soft fluctuating swelling. In sarcomas of the base of the skull the rupture usually takes place into the nasopharynx. Malignant growths of endocranial origin rarely lead to metastases.

SURGICAL EPILEPSY

Epilepsy sometimes follows cranial and other injuries. It may be due (1) to peripheral nerve irritation either arising in a scar in the soft parts covering the skull or following an injury in the neighborhood of one of the large nerve-trunks of an extremity, particularly the sciatic nerve (**reflex epilepsy**); (2) to changes in the bones of the skull or in the dura (**exostoses, adhesions, etc.**); (3) to the effects of injuries of the cortex.

In cases resulting from **peripheral nerve irritation** the irritating influences start from the scar; if this is excised before the so-called "convulsive state" of the brain has been established by repeated attacks, provided hereditary influences can be excluded, a cure may be hoped for. Otherwise the condition is a permanent one, that is to say, slight causes will produce the seizures, these occurring with increasing frequency.

Scars of the scalp are the most frequent cause of surgical epilepsy. These are usually sensitive to pressure, which may bring on an attack. They may have been the previous seat or starting-point of neuralgic pains. The site of healed fractures of the skull, not necessarily those that are depressed, may

behave in like manner. Healing at the site of a bone defect of the skull is quite as likely to give rise to surgical epilepsy as that of an old depressed fracture.

Changes in the cerebral cortex resulting from changes in the motor area or from diseased conditions of this area produce epilepsy (**cortical** or **Jacksonian epilepsy**). The essential feature of a convulsive seizure originating in cortical epilepsy is its occurrence on the side opposite that of the seat of the irritation. The sequences of cranial injuries not involving the cortex alone, as well as surgical epilepsy from other causes, give rise to general convulsions.

Surgical epilepsy of a reflex character is never the result of a recent wound. Its appearance is always delayed until cicatrization is complete, and it may follow years afterward. In cases in which epileptiform convulsions occur immediately after or soon after the reception of a cranial injury, these are due to injuries of the central cortex or to the pressure of bone splinters or other foreign bodies.

Treatment.—Operative treatment, to be of any avail, should be resorted to before changes in the brain occur. Removal of the scar is the first step and may suffice. This failing, the skull should be opened by an osteoplastic resection, and if nothing abnormal is found (the presence of a cyst, etc.), the bone flap is to be replaced after a finger's-breadth is removed from its circumference, the relief of intracranial pressure thereby being provided for (Kocher). Lumbar puncture, puncture of the ventricles, and even drainage of the ventricles have also been recommended with the same aim in view. In cases occurring in connection with a bony defect in the skull good results have been obtained by osteoplastic procedures designed to cover these in (Bergmann). Resection of diseased portions (Horsley's excision of a motor center) has been performed, but with widely varying results in the hands of different operators. On the theory that the epileptic attacks are due to vasomotor spasm Alexander suggested the removal of the upper cervical sympathetic ganglion (**cervical sympathectomy,** see page 640). Jonnescu's experience in the removal of all three of the cervical sympathetic ganglia entitles the operation to further trial.

ENCEPHALOCELE

It is impracticable to differentiate congenital encephalocele, meningocele, and meningoencephalocele. The bony covering develops but incompletely over the brain; the latter, in some instances, is arrested in its development. The tumor is found in the middle frontal region or glabella; behind the mastoid process; in the occipital region; in the cervical region; finally, a very rare form is found in the fauces, passing down in a bony fissure between the ethmoid and the sphenoid bone. These locations correspond to the locations of the ventricles from which the tumors develop. The tumors are not found in connection with the fontanels. The occipital encephalocele is the most frequently observed; the mastoid is very rarely seen. That which occurs in the frontal region is usually very small, rarely exceeding a hazelnut in size.

The **diagnosis** of congenital encephalocele is based on its location and history. Tumors of this class are most liable to be confounded with dermoid cysts.

Treatment should not be instituted as long as there is no tendency for the tumor to increase in size. More than one life has been sacrificed in the attempt

to deal surgically with these tumors. Where, however, the coverings become very thin from growth of the tumor and threaten perforation, aseptic aspiration of a given quantity, perhaps less than a dram, followed by the injection of an equal quantity of Lugol's solution, may be tried. The needle should not be introduced directly through the thin coverings, but at a distance from the base, in the healthy scalp. The aspiration and injection may be repeated once a week. This failing, extirpation by an elliptic incision at the base and accurate coaptation and suturing may be resorted to. In the large pedunculated encephalocele of the newborn a double thread, carried through the pedicle and tied on each side, followed by removal of the tumor and suture of the gap, has had favorable results (B. Flothmann). In extirpation of the tumor failure of union results fatally, ventricular fluid continuing to flow from the gap until the end. In the occasional occurrence of an encephalocele with a small pedicle there is a great temptation to encircle the same with a ligature. Usually, however, the gangrenous inflammation which results passes beyond the site of ligation and death follows.

HYDROCEPHALUS

The fluid in hydrocephalus may be situated in the cerebral membranes or inclosed in the cavity of the ventricles (external and internal hydrocephalus). In the majority of cases the latter condition obtains. Hydrocephalus usually has its origin at birth, and continues to develop; postnatal origin is rare. Separation of the sutures, attenuation of the bones, and enlargement of the fontanels are the salient pathologic features in the beginning. In the course of the disease nuclei of bone are found, these representing an attempt at the formation of the Wormian bones. Rachitis is to be considered as favoring the development of the disease, rather than as originating it, though coexistence of hydrocephalus and rachitis is of frequent occurrence.

Internal treatment is useless. Compression by bandages has not been followed by gratifying results.

Operative treatment should always be tried in severe cases of a progressive character that menace the patient's life. The question of operating in cases in which life is not threatened, but in which progressive idiocy is manifest, is still *sub judice.* Opinions differ as to the justifiability of interfering under these circumstances. The grave risks which are run, whether the indication is vital or psychopathic, are such as to cause the surgeon to hesitate before interfering.

Puncture may be performed either at the site of one of the sutures (the sagittal suture being avoided on account of the proximity of the longitudinal sinus) or through the orbital vault (Langenbeck). The latter situation is the preferable one, both because of the thinness of the roof of the orbit, and because one of the most dependent portions of the ventricular system is reached from this point. Less septic material is likely to be carried in with the trocar than if the skin is punctured, and the eyelid closes over the opening, assisting in protecting the latter from subsequent infection. The upper eyelid is raised, the trocar is passed through the retrotarsal fold, and with a firm thrust is made to perforate the thin orbital plate. The puncture must be repeated several times; but little fluid is obtained at each puncture, owing to the inelasticity of the cranial walls and the desirability of not permitting air to enter. Aspiration seems to offer but slight advantage.

THE SOFT PARTS OF THE FACIAL REGION

Injuries of the Facial Region.—Wounds of the face, owing to the vascularity of the parts, bleed freely. With the exception of some of the larger branches of the facial artery, however, the application of a ligature is seldom required. This same vascularity, also, explains the almost invariable occurrence of healing by first intention noticeable in wounds in this region. Even in tissues much lacerated and contused, sloughing is a rare circumstance. Nature's efforts are frequently so successful in filling up defects that plastic procedures are best deferred until complete cicatrization takes place.

Cicatricial ectropion of the eyelids and lips occurs from burning accidents. In case of the latter, the surgeon should never fail to warn the patient or his friends of the probability of such an occurrence. The burns from hot water, caustic liquids, and chemic substances driven against the face in laboratory accidents are usually deeper than at first appears and frequently involve an unfavorable prognosis, as far as the cosmetic effect and the function of the parts are concerned. In the case of the lower lip the saliva trickles away and the formation of labial sounds is interfered with. Ectropion of the eyelids permits the tears to flow over the face and the globe of the eye suffers in consequence. Extensive formation of cicatricial tissue at the lateral aspects of the cheeks embarrasses the movements of the inferior maxilla. Operative interference is here demanded (see page 531, Cicatricial Lockjaw).

The presence of **powder grains** in the **skin of the face** involves considerable disfigurement. When recent, the greater portion of them can be removed by vigorously scrubbing the face, under an anesthetic, by means of a coarse and stiff hand-brush (Richardson). A cataract needle applied to each powder grain, if the case is not seen until late, will remove these in the course of time, though the process is a tedious one. The prolonged application of a solution of mercuric chlorid is said to facilitate the extraction (Hebra).

Simultaneous wounds of the skin and mucous membrane require separate suture of these structures. This is particularly true of the eyelids. Perforating wounds of the oral cavity, if permitted to cicatrize, leave fistulous openings through which liquids escape, as well as mucus and saliva. Stenson's duct may be involved in the injury, and the parotid secretion poured on the outside of the face (see page 587, Salivary Fistula).

Traumatic Inflammation.—While the extreme vascularity of the soft parts in the facial region would tend to favor the extension of septic processes, it is nevertheless true that these are of rather infrequent occurrence. This is mainly due to the peculiar arrangement of the subcutaneous connective tissue which passes directly at right angles to the surface to embrace the subcutaneous muscles. Though wounds in the neighborhood of these muscles gape widely, yet the peculiar arrangement of the connective-tissue fibers prevents propagation of septic inflammatory processes. In other parts, however, as, for instance, in the eyelids, the fibers of the connective tissue are arranged parallel to the fibers of the orbicularis palpebrarum, and phlegmonous inflammation is more likely to occur. Destruction of tissue here may give rise to cicatricial shortening of the integumentary surface of the eyelid and consequent ectropion. Extension of the septic process through the medium of the palpebral fascia

and along the muscles of the globes or sheaths of the nerves into the mass of fat behind the globe itself, and thence through the superior or inferior orbital fissure to the brain, may occur.

The most characteristic symptom of septic inflammation about the face is extensive edematous swelling of the parts involved. This is due partly to venous and lymphatic congestion and partly to serous infiltration. Erysipelas infection likewise produces edema. The occurrence of erysipelas in the face may lead to its extension to the scalp and give rise to the peculiar dangers which result from the presence of this infection in that region. Septic thrombi in the facial and orbital veins may cause **metastatic pyemia.** Taking it all in all, therefore, though this region in all its parts is not particularly prone to inflammatory septic processes, yet in localities where these do occur, serious results may follow. To add to the difficulties, the presence of the nares and mouth somewhat embarrasses the efficient application of antiseptic dressings. The use of collodion mixed with subiodid of bismuth or iodoform (Küster), penciled over the wound edges after coaptation of these, is here very useful.

Nontraumatic Inflammation.—Eczematous conditions of the skin of the face in children are of interest to the surgeon principally from the lymphatic glandular involvement near the angle of the jaw, which is likely to follow.

In addition to ordinary bacterial infection, the integument of the face is liable, through the open follicles, to invasion of the so-called thread fungi. The special varieties of inflammation caused by the presence of these vegetable ectoparasites may be simply mentioned; they belong particularly to the domain of dermatology: favus; sycosis or mentagra; blepharadenitis or inflammation at the ciliary margin. The inflammatory conditions arising from these are so slight compared with those which arise from common bacterial infection as to amount to scarcely more than an irritation.

Acne pustulosa is the least important of the acute inflammations of the sebaceous glands. The small pustules may, however, lead to deeper infection, in which case a furuncle develops. **Hordeolum** or **sty** is an inflammation of the sebaceous glands at the tarsal margin. **Carbuncle** develops most readily at the lips and cheeks, the short connective-tissue fibers in these localities favoring constriction of the vessels and early sloughing in the presence of specific microorganisms. Carbuncle in these situations is a very serious affection, erysipelatous infection readily occurring and spreading. **Pyemia** from thrombosis of the facial vein may occur. Such energetic measures as total excision of the carbuncle in severe cases are here justifiable, despite the possibilities of subsequent cicatricial deformity. Even in mild cases nothing short of early crucial incision and vigorous curetting will suffice.

Noma.—This is a peculiar affection of the mucous membrane of the cheek. A diphtheritic inflammation of the mucous membrane of the cheek is followed by gangrene. A small black spot first appears which increases rapidly in size. General infection may follow, or the sloughing mass may be cast off, cicatrization taking place with a peculiar star-shaped scar. Considerable deformity of the angle of the mouth occurs, the latter being drawn outward and upward with exposure of the teeth. Fixation of the jaw from cicatricial lockjaw may also occur. Operative interference is here necessary in order to restore the function of the parts.

Various causes have been assigned for noma. From the fact that it develops

at first at the orifices of Stenson's duct, it has been thought that mercurial salivation, if it does not actually produce the disease, at least predisposes to it. This circumstance, at least, suggests that care should be exercised in the use of mercurials, particularly in children suffering from scarlatina, in the course of which disease noma is particularly liable to develop. A microorganism that seems morphologically the same as the Klebs-Löffler bacillus of diphtheria has been identified in these cases. The **treatment** consists in freely applying the thermocautery to the gangrenous area and packing the resulting cavity with frequently changed compresses wet with solution of hydrogen dioxid.

Facial Erysipelas.—This disease was formerly relegated to the domain of internal medicine under the belief that it was an idiopathic affection. The disease, however, depends on the presence of a specific microorganism (see pages 27 and 178) which finds its entrance into the depths of the skin probably through some slight fissure or excoriation, at the site of an acne pustule, or through the follicular openings on the nose, which, in this locality are unusually large. Its course is similar to that observed in the case of wounds, and the same treatment is applicable.

Herpes labialis is without special interest to the surgeon. **Herpes rhagades** is that variety of herpes which appears at the angles of the mouth and is sometimes a symptom of general syphilitic infection.

Lupus as it attacks the facial region appears by preference on the cheeks and lips, though it may attack the eyelids. In the latter situation, it is usually an extension from the nose. (For Nasal Lupus, see page 501.) It may appear in the **hypertrophic, ulcerative,** or **exfoliative** form. The first named is much rarer on the cheek than on the nose and eyelids. The ulcerative form occurs more commonly on the cheek, thence extending to the lips and region of the chin. The secretion dries on the ulcerated surface, forming dark and foul-looking crusts. The ulceration very rarely passes to a depth sufficient to invade the fatty structures beneath; hence invasion of the cavity of the mouth is not observed. In the case of the lips, however, the entire thickness is invaded, and extension to the gums likewise takes place. The presence of a less amount of fatty tissue and the preponderance of muscular structure in the lips accounts for the greater tendency to deep and destructive ulceration in the latter region, as compared with the cheeks. Primary lupus of the lips is rare, however; its occurrence here is usually the result of extension from the nose or cheeks. The exfoliative form of the disease may extend from the face to the region of the neck. It likewise occurs as an independent process and is characterized by its disposition to extend over larger areas without tending to pass deeply into the skin.

In the **treatment of lupus** radical measures are indicated in the severe forms. These include excision in some cases, and the use of the actual cautery or caustic applications in others. In any event, destruction of the lupus tissue is imperative. When excision is practised, the immediate transplantation of strips of skin by Thiersch's method (see page 331) gives the best results (Senger). The employment of skin grafting after the manner of Reverdin also gives good results. In cases in which these procedures are not applicable, as, for instance, where the entire thickness of the lip, or the nose, is destroyed, plastic operative procedures are to be employed (see page 509).

It has been observed that, after the transplantation of new tissues from a distant part, lupus tissue which has been left behind disappears.

Microstoma results from cicatricial contraction of the mouth and is to be treated by a stomatoplastic procedure (see page 493).

TUMORS OF THE CHEEKS, LIPS, AND EYELIDS

The congenital tumors of the facial region include **capillary angiomas** and **pigmentary nevi.** The former are characterized by flat propagations on the surface, or subsequently to their appearance on the skin they may develop within the deeper structures (parotid gland, etc., see page 227). Extirpation and subsequent plastic operations are sometimes required.

Pigmentary nevi and more rarely **warty nevi** develop at the margin of the mucous membrane of the lower lip; in this situation they sometimes precede the development of carcinoma.

Congenital hyperplasia of the labial substance is sometimes observed. The thickening may be due to an excessive thickening of lymph-vessels (lymphangioma) or the hyperplastic condition may refer more to the mucous membrane, becoming visible as a "double lip" during the act of laughing. **Scrofulous edema** of the lips is confined to the upper lip and is usually associated with eczema, chaps, etc. Compression by means of elastic bandages is the best treatment (K ö n i g). **Mucous cysts** from retention of secretion are rather frequent. They are thin walled and vary from the size of a pea to that of a hazelnut.

Lymphangiectatic congenital cysts are found beneath the mucous membrane of the cheek (V o l k m a n n). A mucous cyst is to be distinguished from the **cysticercus cutis** sometimes found near the orifice of the mouth; it is about the same size but is more deeply situated. The tissues about the latter are more solidly infiltrated than in mucous cysts. **Adenoma** of the lips is rare.

The lips are very rarely the seat of **atheroma;** this occurs, however, in the cheek and eyelids. (See page 235 for Dermoids.) **Lipoma** originates from the deep adipose tissue of the middle of the cheek. **Fibroma** is also observed in the cheek.

Leontiasis is a hyperplasia of the skin of the face in which the skin of the cheek, eyelids, and lips hangs down in long folds; the disease takes its name from the peculiar appearance of the patient. It corresponds to elephantiasis in other portions of the body. Ligation of the common carotid arteries has been successfully employed for its cure (C a r n o c h a n).

Adenoma of the sweat-glands consists of a flat elevation of the skin and has a dark red appearance. The color is due to increased proliferation of the vessels. It should be distinguished from the hypertrophic form of lupus; the latter possesses a tendency to extend not present in the former. Its relation to carcinoma has been demonstrated (K ö n i g). It selects by preference the skin at the junction of the nose and cheek.

Intraocular sarcoma may affect the retina, the iris, or the optic nerve. The first named, known as glioma, occurs exclusively in children during the first four years of life. Both retinas are affected in about one-fifth of the cases. The symptoms are dilatation of the pupil, followed by complete blindness.

As the tumor increases in size the intraocular structures are pushed forward, pain is present as the intraocular tension increases, and a fungating mass makes its appearance. This bleeds easily and a sanious discharge is present. There is little tendency to broad dissemination, secondary deposits, as a rule, being confined to the brain, the lymphatic glands, and the periosteum of the orbit. Extirpation in the late cases is followed by recurrence in these parts, while in the early cases it occurs in the stump of the optic nerve. **Intraocular sarcomas of adults** are always of the pigmented type and almost without exception occur unilaterally. They appear, as a rule, between the fortieth and the sixtieth year of life. Dissemination is the rule, and recurrence almost invariable, even after the lapse of years. The brain is very rarely involved, and adjacent lymph-glands are almost never infected. Death usually takes place from secondary deposits in important organs. Life may be prolonged, however, by early extirpation of the globe.

Fig. 248.—Rodent Cancer of the Face.

Rodent Ulcer.—This is a name given to a form of cancer which may attack any or all of the glandular or epithelial structures of the skin of the facial region (Fig. 248). It probably arises in the sebaceous glands (Sutton). Though its favorite location is the face, it may occur on the neck or pinna, and is occasionally met with on the trunk. It is most common in advanced life, but is occasionally seen between the ages of thirty and fifty. It is observed more frequently in men than in women.

The simple nodule which heralds its appearance may remain stationary for years, when, without apparent reason, it may break down, and rapid ulceration of the surrounding parts take place without regard to their structure. Once the destructive process is initiated, it is never arrested except by complete excision, though the disease may last for years and give rise to no pain and very little discomfort except that of a mental character from the horrible disfigurement which it occasions.

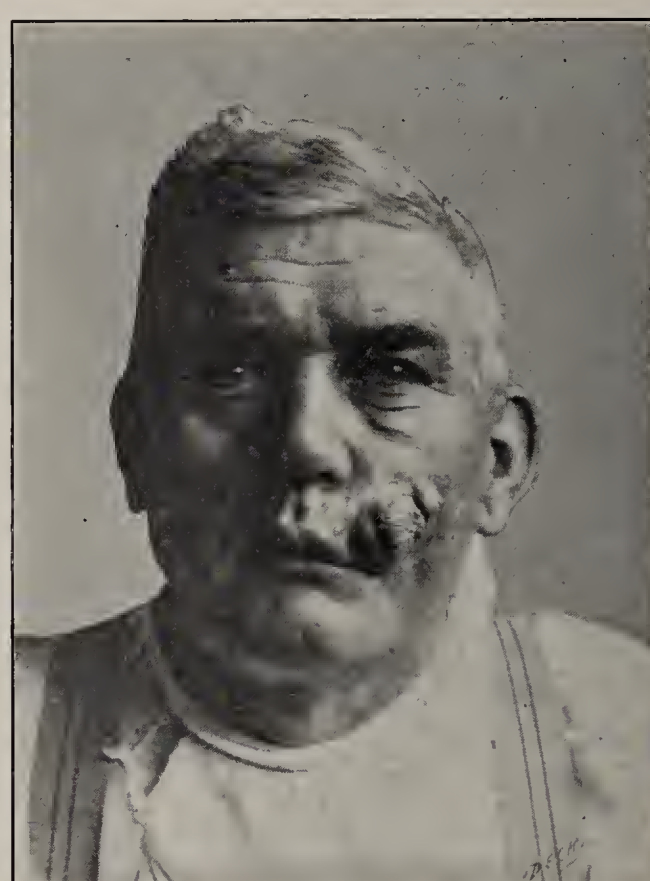


Fig. 249.—Epithelial Carcinoma of the Cheek.

Section of the nodule before ulceration sets in shows this to be made up of gland ducts filled with epithelium, or of solid cylinders. Though the progressively destructive course of the disease and the certainty with which it finally

causes death, stamp it as of a malignant nature, yet some of the other characteristic features of malignancy, namely, lymphatic glandular infection, dissemination, and rapid growth, are absent.

It is generally found on the cheek and eyelids. It may extend to the forehead and involve a portion of the scalp (Fig. 248). Sometimes it develops on cicatrices at the site of old burns, or of wounds, or of lupus. It is slow of growth; cicatrization in the region of the lips and eyelids leads to ectropion of these. Other forms of **carcinoma** found are the epithelial variety, which selects the lips, particularly the lower lip, and the papillomatous. The latter is characterized by proliferation of papillomatous structure and attacks the mucous membrane lining the cheek. This variety is to be distinguished from syphilitic mucous patches; carcinoma in general in these regions is to be differentiated from syphilis and lupus.

Carcinoma of the Lips.—This is most frequently observed between the thirty-fifth and the sixtieth year and shows a marked preference for the lower lip in men. In the rare cases in which it occurs in the **upper lip** it is found in both sexes in about equal proportion. The submaxillary lymphatic glands are early infected, form large masses, and finally implicate the skin. Death takes place from combined septic and anemic conditions, hemorrhage, or septic pneumonia. In the natural history of the disease the average duration of life is one year.

Carcinoma of the lower lip affects men almost exclusively. In 62 cases only one was found in a woman (Winiwarter). Inhabitants of rural districts are said to be more frequently attacked than the residents of cities. Whether or not smoking is the cause of the disease, it is none the less true that persons who have never smoked suffer from the disease. The place of its occurrence on the vermilion border, about half-way between the median line and the oral angle, probably first suggested its name of "smoker's cancer." An epidermal thickening first appears, or a warty excrescence which bleeds easily; ulceration soon follows. The ulceration usually spreads, first in a horizontal direction, and toward the angle of the mouth; afterward in a vertical direction. Sometimes the ulceration passes in a downward direction, involving the region of the chin. In cases of long duration the growth may reach the angle of the mouth, pass to the upper lip, and finally reach the other angle of the mouth. The ulceration has a characteristically hardened base and an infiltrated edge. The disease may pass to the mucous membrane of the mouth, cross the gingival fold, and attack the mucous membrane of the gums.

Glandular Involvement.—The lymphatics from the lower lip empty into the lymphatic glands below and behind the angle of the jaw; occasionally they communicate with those in the region of the myohyoid and geniohyoid muscles. The first named situation is the site of the first set of glands concerned in secondary glandular involvement in carcinoma of the lower lip. They are best examined by passing the finger between the tongue and the jaw and crowding the groups of glands against a finger of the other hand placed on the outside. Glandular involvement not discoverable by ordinary methods of examination can be made out in this manner.

Diagnosis.—No difficulty is encountered in diagnosing carcinoma of the lower lip. The only disease with which it can possibly be confounded is the initial sclerosis of syphilis (hard chancre). In individuals below thirty years

of age an ulcer with an indurated base and infiltrated edge *may* be a hard chancre; in those above thirty, it is almost *sure* to be carcinoma. In case of doubt a course of mercurial inunction will settle the question. Valuable time may be lost in this way, however, and it were better to extirpate any number of suspicious ulcerated patches on the lower lip than to err in the other direction and by delay sacrifice a life.

Carcinoma of the Upper Lip.—The occurrence of the disease in this situation is very rare (5.4 per cent, Loos), excluding the carcinomas which have their origin in the lower lip.

Epithelial carcinoma is the variety of the disease met in these regions almost exclusively.

The Operative Treatment of Carcinoma of the Lip.—If the disease is diagnosed early, a simple V-shaped incision extending through the entire thickness of the lip and carried in all directions well beyond the limits of the disease (one-quarter of an inch at least) will, in the great majority of cases, effect a permanent cure (Fig. 250). If no glandular involvement is present, so simple is this operation and so rapidly is it accomplished, that even an anesthetic is not required, or, at least, cocain local anesthesia is all that is necessary. A few vigorous strokes with a pair of stout scissors suffice for the extirpation. The lip should be grasped firmly with the thumb and forefinger of the left hand, the fingers of an assistant at the same time grasping the mouth at the angle in order to arrest the hemorrhage from the coronary arteries. Or, a narrow bladed scalpel may be employed, the angle of the V being transfixed and the incision carried upward through the border of the lip, first along one of the dotted lines shown in the figure, and then along the other. The narrowing of the mouth consequent on suturing the gap will be soon compensated for by changes in the angles of the mouth, these becoming elevated in such a manner that the relatively increased length of the upper lip is in time partially transferred to the lower.

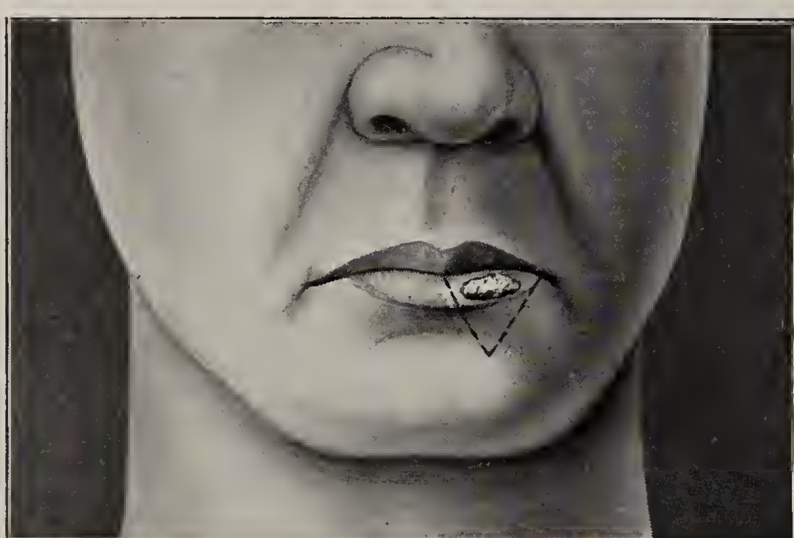


Fig. 250.—Carcinoma of the Lower Lip. The dotted lines show the direction of the common V-shaped incision for extirpation of the growth.

As in harelip, the first suture is to be applied in such a manner as to arrest hemorrhage from the vessels. In case difficulty is experienced in closing the gap, the tension should be relieved by relaxation incisions; these, however, are rarely necessary. The suturing of the mucous membrane at the margin of the lip should be done carefully. It may be necessary to apply separate sutures to the mucous membrane lining the lip. Alternate tension and superficial or approximation sutures are to be applied. A dressing of iodoform or subiodid of bismuth collodion is sufficient protection applied along the line of sutures. The mouth should be washed out occasionally with either a boric acid or biborate of soda solution, particularly after taking food. (For Cheiloplasty, see page 482.)

Not only should enlarged and hence diseased lymphatic glands be sought on the corresponding side of the neck during the operation, but on the opposite side as well. On no account should they be looked upon as inflammatory in origin. On the slightest sign of a recurrence of the disease, the operative procedure is to be repeated. A slight thickening or wartlike appearance in the neighborhood of the scar should receive immediate attention.

It is surprising to what extent portions of the lower lip can be repeatedly removed and yet the narrowed oral opening regain a fairly comfortable size from changes which occur at the angles.

In cases in which late operations are performed the latter may necessitate resection or excision of the lower jaw as well. The involvement of the bone may result from an extension of the primary focus along the mucous membrane to the gingival coverings, and thence to the osseous structure; or it may be due to an extension of the disease from secondary involvement of the glands lying close to the angle of the jaw in the neighborhood of the facial artery. These latter are almost invariably involved, even early in the disease. The close proximity of these to the periosteum leads to early extension to the latter and thence to the bone, once the glands are affected.

The prognosis in late operations is very unfavorable. Even with removal of the primary focus and extirpation of all apparently diseased glands, the deeper lymphatic structures, particularly those adjacent to the cervical spine, become involved to an extent which precludes the possibility of removal.

Carcinoma of the Cheek.—This is often confounded with syphilitic ulcer. It is sometimes preceded by leukoplakia. In frequency of occurrence it stands midway between carcinoma of the lips, tongue, and floor of the mouth, which are very commonly affected, and carcinoma of the hard and the soft palate, which are comparatively rarely attacked. It occurs more frequently in males, and particularly in those who smoke or chew tobacco. In the majority of cases the disease originates in the cul-de-sac between the gum of the lower jaw and the cheek, whence it ascends along the alveolar process, attacking the gum and periosteum and the buccal mucosa as well. It may commence at the angle of the mouth. The submaxillary lymphatic glands become involved early. The cheek is soon perforated and a fistulous opening leading into the cavity of the mouth results. The submucous tissues are infected more rapidly than the mucous membrane. Inflammatory symptoms sometimes supervene; subperiosteal abscesses may develop and phlegmonous and erysipelatous conditions are not infrequently observed.

The **prognosis** is grave. The disease runs its course rapidly and the great majority of patients come to the surgeon too late for successful operative interference. In advanced cases the usual yellow hue of cancerous cachexia is replaced by a peculiar pallor, which constitutes a contraindication to operation.

Treatment.—Extirpation is the only resource. This must include the adjoining bone with its coverings. The incisions commence at the angle of the mouth, radiating from this point backward, so as to include all the affected tissues. The involved glands are first dissected out, the dissection going wide of these. In the case of the lower cul-de-sac the inferior maxilla is sawed through in front near the median line, the floor of the mouth detached, and the ascending ramus sawed through. The jaw is now drawn forward and the

entire thickness of the cheek extirpated with the tumor and bone still attached by dividing the pterygoid and remaining attachments. In the case of the upper cul-de-sac the corresponding half of the upper jaw and the carcinomatous mass must be removed. In closing the wound, the mucous membrane of the floor of the mouth is detached up to the tongue, and sutured to the edge of the divided mucous membrane of the cheek, and the edges of the skin wound sutured. The after-treatment is the same as in carcinoma of the tongue,

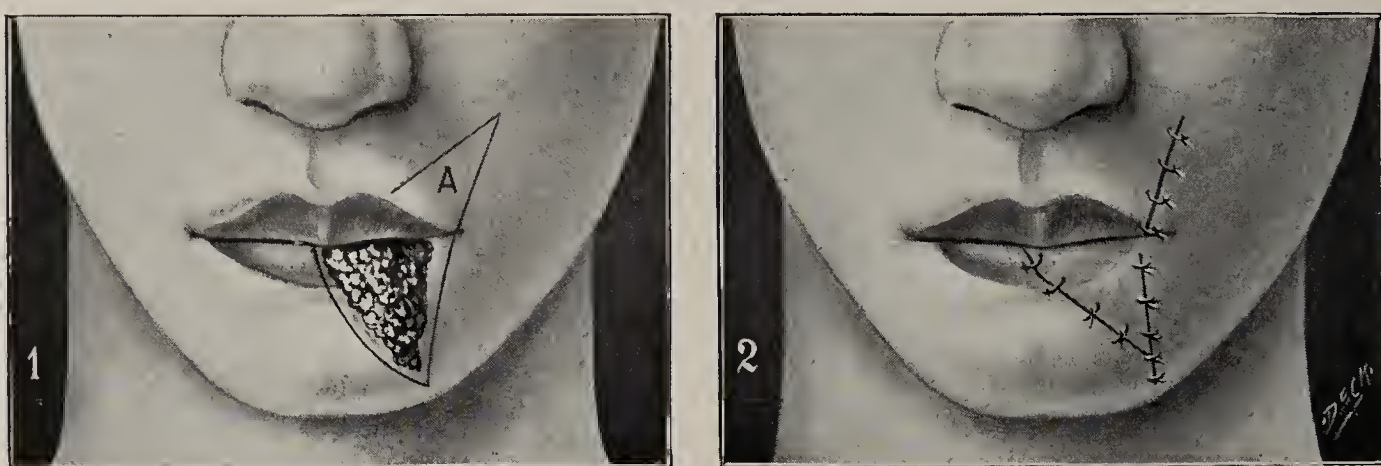


Fig. 251.—Estländer's Cheiloplasty.
1. A, Portion taken from upper lip and cheek to fill defect. 2. The parts as they appear after suturing.

namely, frequent irrigations with boric acid solutions, spraying with hydrogen dioxid, and the twice daily application of a 10 per cent solution of chlorid of zinc.

Carcinoma of the Gum.—The favorite starting-place for cancer of the gum is the mucous membrane covering the lower alveolar processes; not infrequently the site of a carious tooth is selected. Early infection and massive enlargement of the glands of the neck occur. Some of the reported cases of

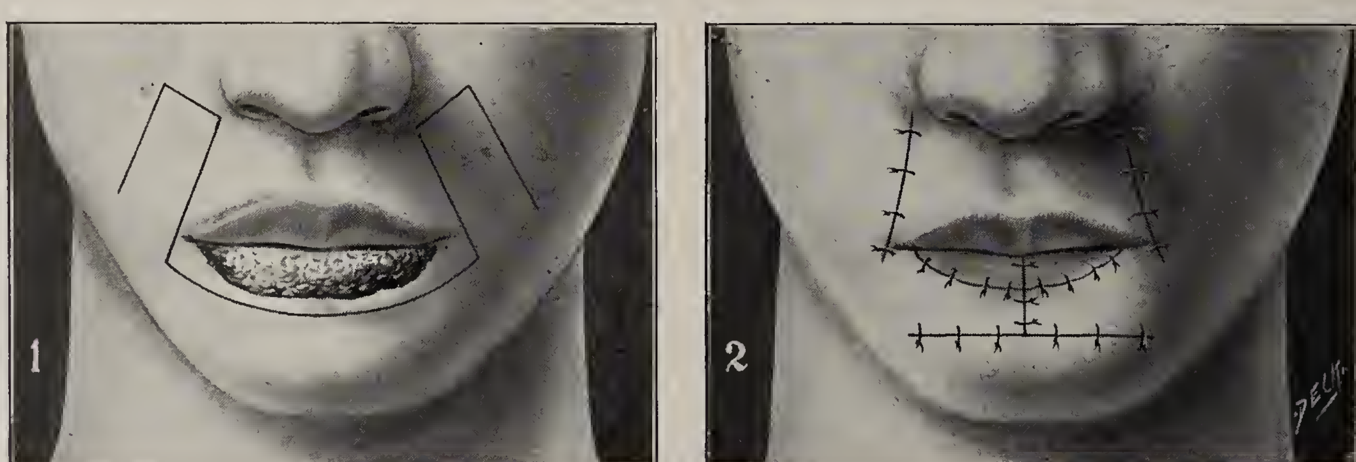


Fig. 252.—Bruns's Cheiloplasty.
1. Showing the lines of incision for the removal of the disease and supplying the defect. 2. Showing the position of the parts after suturing.

primary carcinoma of the neck were in all probability the result of glandular infection from small and undiscovered epithelioma of the mouth or of contiguous parts. The adjacent bony parts are invaded to an extraordinary extent. In the somewhat rare cases in which the disease occurs in the mucous membrane of the alveolar processes of the upper jaw, the antrum is opened and the disease invades its cavity.

Cheiloplasty.—In cases in which it may be deemed desirable to replace

the lower margin of the lower lip immediately after an operation for carcinoma, this may be done by the operation devised by Estländer (Fig. 251). A flap, the base of which is formed at the upper lip, is taken from the cheek and carried down to assist in filling up the gap in the lower lip. If care is exercised

Fig. 253.—Langenbeck's Cheiloplasty.
1. Lines of incision. 2. Appearance of the parts after suturing.

in shaping the flap, it will contain the superior coronary artery, which will aid in its nutrition.

Special operative procedures are to be instituted in cases in which the disease is more extensively distributed. When the entire lower lip is involved, the plastic procedure of Bruns, in which the defect is supplied from the cheek, will replace the lost tissue (Fig. 252). After this, as, in fact, after all plastic operations in this region, the normal elastic lip is substituted by a flap with cicatricial edge. As time passes, this edge contracts and is drawn tightly against the lower jaw; saliva runs over the edge in spite of every effort to prevent it. The ingeniously contrived plastic procedure of Langenbeck (Fig. 253) possesses an advantage in that a beard can be grown in such a manner as to hide the lines of the union.

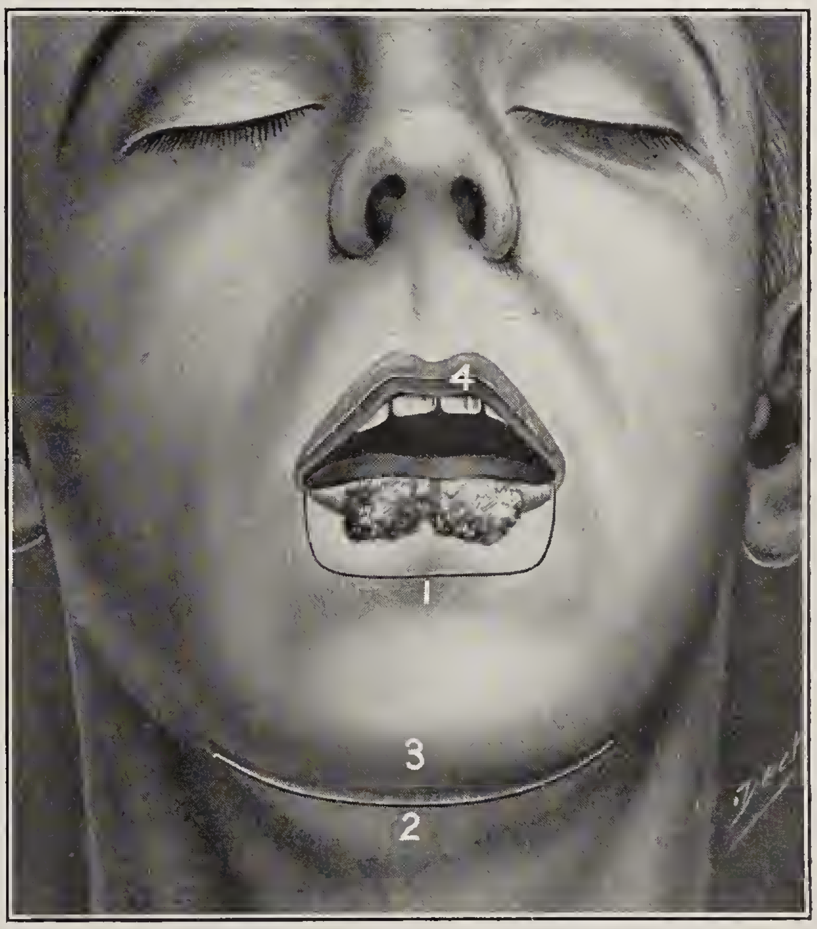


Fig. 254.—Sandelin's Method of Cheiloplasty.
1, Line of incision for the excision of the growth; 2, line of incision for the formation of the visor flap of Morgan; 3, the visor flap; 4, Schulten's line of incision for the formation of a mucous membrane and muscle flap taken from the upper lip.

Sandelin's Method of Cheiloplasty.—Sandelin combined the method of sliding a visor-like flap in an upward direction to cover the lip (Morgan) with Schulten's method of transplantation of a flap taken from the upper lip and including both mucous membrane and muscular tissue. The method is as follows: The edge of the defect is first carefully freshened. A transverse curved incision is then made

below the chin in the anterior region of the neck (Fig. 254). The soft parts are now dissected from the chin and below the latter to an extent sufficient to permit sliding upward of these until the edge of the defect can be placed on the proper level without tension, where it is secured by a short steel nail driven through the flap and into the bone. A curved incision is now made in the upper lip to the depth of from three-eighths to half an inch. This incision splits the lip so as to form an anterior and a posterior layer. Care must be taken in making this incision and splitting the lip to include both muscle and mucous membrane, and to preserve the coronary artery in the posterior layer of the flap that is to be transplanted. Accidental injury of the coronary artery will result in sloughing of the flap. The latter is now detached, except at its extremities, and brought down and sutured to the skin edge of the defect (Fig. 255). In suturing the flap the sutures near the angles must be accurately placed, in order to preserve proper symmetry of the mouth, and to avoid subsequent shrinkage.

Fig. 255.—Sandelin's Method of Chelioplasty. The operation completed with the exception of the closure of the visor flap incision.

The defect left in the upper lip is corrected by suturing its edges with chromicized catgut, and the gap left in the anterior portion of the neck is closed by loosening and sliding its edges and suturing (Fig. 255). The amount of tissue taken from the upper lip, although considerable, is scarcely missed. Both the functional and the cosmetic results are said to be excellent.

CONGENITAL MALFORMATIONS

These include cleft defects, *i. e.*, labial cleft or harelip, vertical cleft of the cheek, and horizontal cheek cleft forming a macrostoma or enlargement of the mouth, conjoined with which there is usually an appendix of the skin in front of the corresponding ear. Of these, harelip is the most common; this is confined almost exclusively to the upper lip. Cases of cleft in the lower lip are very rare, though such have been reported. Simultaneous clefts of the inferior maxilla and tongue, in addition to cleft of the lower lip, have been observed. Fistulas of the lower lip may occur in connection with harelip.

HARELIP

This may be single, double, or complicated with cleft palate. Almost without exception, it is laterally placed in the line of one or the other nares. In the rare instances reported, in which the median cleft was present, deformities

involving absence of the ethmoid, turbinated bones, nasal bones, vomer, and premaxillary bone were also present. Single harelip and double cleft occur in the proportion of ten to one; harelip is more common on the left side.

Three degrees of harelip are recognized. The first is a mere notch scarcely passing beyond the vermilion border; the second extends nearly or quite to the nasal orifice and there terminates (Fig. 256), while the third passes directly into the nasal fossa (Fig. 257). The first two may be uncomplicated; the third is usually associated with cleft palate and failure of union of the premaxillary bone. This degree is often present in single harelip.

Fig. 256.—Single Harelip.

In double harelip the fissures may be of equal length (Fig. 258) or they may be of the second degree on one side and the third degree on the other. The intermaxillary bone is separated from the alveolar arches; it may carry more than the normal number of incisor teeth. At least two fissures exist in the alveloar arch, though but one of these is continuous with the cleft in the hard palate, unless the latter is also double. The prominence of the intermaxillary bone (Fig. 258) is produced by its freedom from restraint; it is crowded forward by the growth of the vomer.

Functional Disturbances.—In simple harelip of the first and second degrees the formation of labial sounds is interfered with. In case of the third degree disturbances of nutrition may result during the first year of life from inability of the child to suckle properly. Bronchitis and pneumonia may likewise occur, from breathing improperly filtered air. In cleft palate the voice assumes a nasal sound.

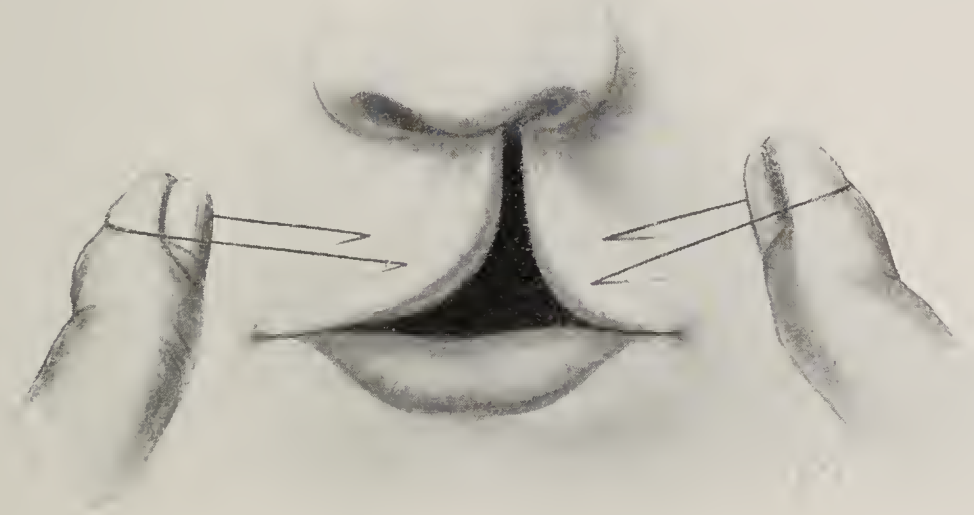


Fig. 257.—The Third Degree of Harelip.
The illustration also shows a method of controlling bleeding from the coronary arteries during the operation.

These congenital clefts are the result of failure of union of the various clefts between the branchial arches in the cephalic extremity. This union normally

occurs at about the ninth or tenth week of fetal life. Incomplete fusion or failure of union results in harelip, cleft palate, and other deformities. The number of instances in which the deformity occurs in the same family suggests a hereditary influence.

The Operative Treatment of Harelip.—The **time** to be selected for the operation is of some importance. While many considerations impel the surgeon to correct the deformity as early as possible, notably those arising from the desire to calm the anxieties of the mother and those referring to the dangers which threaten the child itself, the condition of the child should nevertheless be borne in mind. Swallowing of blood by a newborn infant leads to gastric and intestinal catarrh. Besides this danger, children operated on early do not bear well the loss of blood. Vigorous children artificially fed bear the operation well and may be operated on at any time; in the case of weak and sickly children it is better to defer the operation for a few months, as long as they can take a sufficient amount of nourishment on which to base a hope of improvement in the general condition. Those with double harelip should not be operated on at as early a period as those with single harelip. Cases complicated with cleft palate are advantageously operated on during the first year of life, for the reason that, with closure of the labial cleft, the palatal cleft, during the succeeding few months, grows narrower.

Fig. 258.—Double Harelip and Prominent Intermaxillary Bone.

The Anesthetic.—Chloroform may or may not be administered. While anesthesia permits a more accurate operative procedure, a greater quantity of blood is swallowed, and inspired, as well. If the operation is performed without an anesthetic, the child is wrapped tightly in a small blanket and held by the nurse, the head being grasped by an assistant.

General Technic of Operations for Harelip.—Special pressure clamps for the prevention of hemorrhage are no longer used. The fingers of an assistant grasp the lip on each side of the cleft. A useful device is to pass a loop of thread through the lip at a sufficient distance from the edge to be out of the way, and in a situation to control the bleeding from the coronary arteries (Fig. 257). These loops are held by an assistant. They are removed when the sutures corresponding to the bleeding points are passed and tied.

A straight, thin-bladed bistoury is the best instrument for the formation of the flap. Scissors produce more contusion of the parts. As the flap is being formed it is steadied by mouse-tooth forceps or a small tenaculum. A pair of blunt scissors curved on the flat, half curved needles, and a needle forceps will also be required.

The flap is to be cut after the manner described in Nélaton's, Malgaigne's, the Mirault-Langenbeck, or Simon's method. In order to assure firm union of the sutured edges the wound surfaces are made as broad as possible.

Before the sutures are applied the flaps must be relieved of all tension to prevent the sutures from cutting out. This is done by detaching the lips from the gums by the curved scissors, care being taken to keep the latter close to the gums. The tip of the left index-finger lifts the structures away from the upper jaw in an outward and upward direction and at the same time serves as a guide for the scissors. By keeping the scissors directed toward the upper jaw the vessels are avoided. The relaxing incisions are made on both sides and the frenum of the upper lip is completely separated. The superficial bleeding is arrested by pressure.

The first suture is applied in such a manner as to arrest the hemorrhage. For the rest, alternating deep or tension sutures and superficial or coaptation sutures are used. Particular attention is to be paid to the accurate adjustment of the edges at the vermilion border. Silk thread is to be employed. In tying the knots care should be taken that these do not rest on the line of union, in which situation they are likely to interfere with the accurate adjustment of the edges. Harelip pins are no longer used.

A B

Fig. 259.—Nélaton's Operation for Harelip.
A, The incision; B, sutures introduced.

Methods of Operation in Single Harelip.—Nélaton's Operation.—This is particularly applicable to fissures of the first degree. The lip is transfixed by the bistoury above the angle. The knife is then carried in a direction parallel to the edge of the cleft, downward and toward the vermilion border but not quite to it. This is repeated on the other side, forming a Λ-shaped incision. A tenaculum is passed through the apex and the legs of the Λ inverted, leaving a rhomboid space which is closed by suturing (Fig. 259). An over-correction, as shown in Fig. 259, B, should be obtained in order to allow for subsequent contraction.

Malgaigne's Operation.—The incisions are made as in Nélaton's operation, but the depressed portion is cut through at the apex in order to remove the redundant portion (Fig. 260).

The Mirault-Langenbeck Operation.—This is applicable to harelip of the first and second degree. The method of procedure is shown in Fig. 261. A single flap is taken from above downward, but is left attached at the

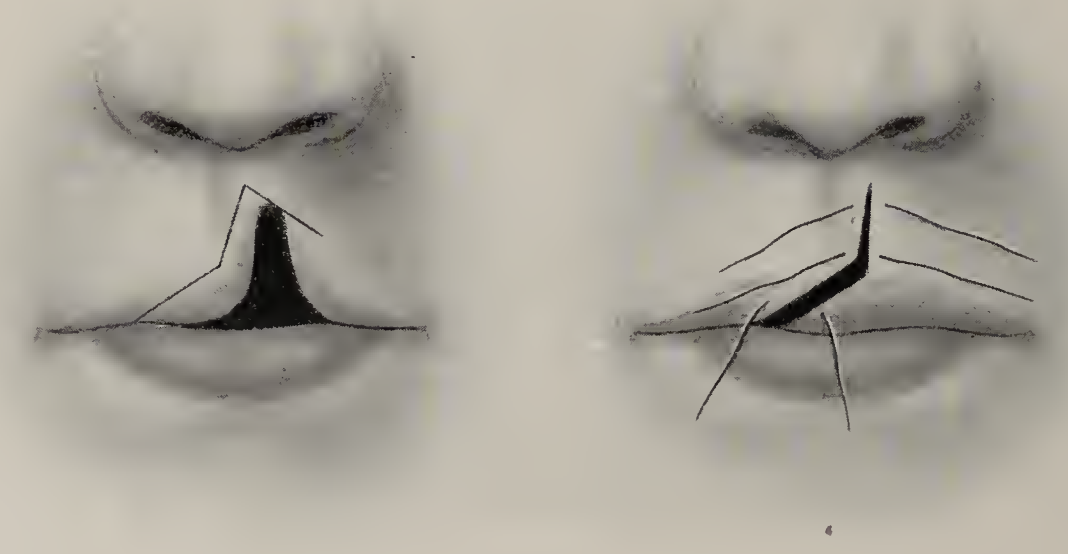
prolabium. The margin corresponding to the median edge of the cleft is freshened at an obtuse angle.

Golding-Bird Operation.—This is useful in harelip of the second degree. The incisions are made in the directions shown in Fig. 262. The line of union resembles somewhat that following the Mirault operation.

A B

Fig. 260.—Malgaigne's Operation for Harelip. A, The incision; B, sutures introduced.

Simon's Operation (Fig. 263).—In this operation the ┗┓ shaped line, when the flap and freshened edge are united, forms a very complete correction of the deformity. The cicatricial contraction is distributed over three separate lines and the minimum amount of shrinkage at the vermilion border occurs. This operation is most useful in harelip of the third degree.



A B

Fig. 261.—Mirault-Langenbeck Operation for Harelip. A, The incision; B, the sutures introduced.

Choice of Operation.—In newborn children and during early infancy and early childhood, other things being equal, the operation which involves the least loss of blood should be chosen.

In harelip of the third degree it sometimes becomes necessary to equalize the openings in the nostrils. When necessary, this can be done after complete

healing and contraction of the parts by detaching the cartilaginous septum at the floor of the nasal cavity and carrying it toward the wider nostril, a place for its reception having been previously freshened. It is here sutured and the side from which it was displaced kept plugged with antiseptic gauze until union occurs.

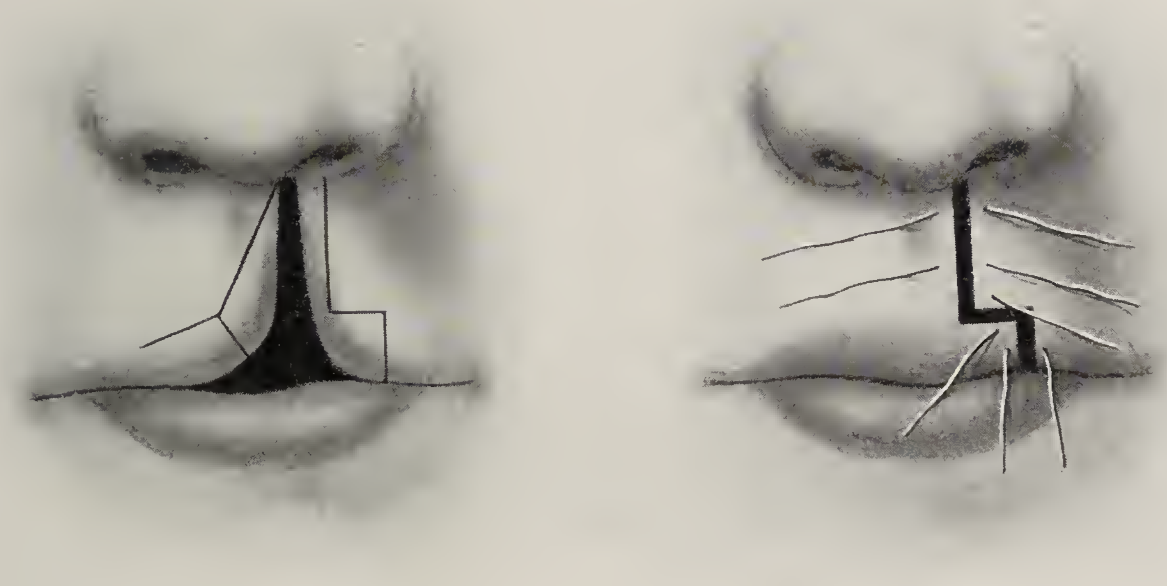
The Operation for Double Harelip.—Time for Operation.—Strong and vigorous children may be operated on at any time. In weak children the operation may be delayed. Even in these, however, failure to maintain the nutrition of the child may necessitate an early operation.

Fig. 262.—Golding-Bird's Operation for Harelip.

Disposition of the Intermaxillary Bones.—In cases in which the projection is but slight or entirely absent the labial clefts may be closed at once. But usually the intermaxillary bone will be found to be a serious obstacle in the way of restitution of the parts.

In favorable cases, with slightly marked prominence, the removal of the labial cleft exercises a favorable influence over both the cleft and the prominent bone; the latter gradually recedes to its normal position and unites with the alveolar process. A considerable prominence, however, will prevent union when the soft parts are brought over the bone.

Under no circumstances must the intermaxillary bone be removed. The functional and cosmetic effects are such as to demand its retention. In order to



A B

Fig. 263.—Simon's Operation.
A, The incision; B, the sutures introduced.

effect its reduction, fracture and the crowding backward of the vomer have been employed; this method is applicable only after ossification of the vomer has taken place. The method of excision of a triangular portion of the vomer close behind the intermaxillary bone (B l a n d i n) is to be preferred. This should be done through an incision made along the edge of the vomer, the mucoperios-

teal covering being lifted with a slender elevator and a Λ-shaped gap made by sharp scissors. A further modification of Blandin's operation consists in making a simple vertical section of the bone. This is done subperiosteally also (Fig. 264). The anterior portion is now forced backward, the lateral surfaces overlapping each other and becoming united (Rose).

The Operation.—The skin overlying the intermaxillary bone is pared at its margins so as to leave a quadrangular space with three wound surfaces. Then, from the outer edge of each cleft a flap is formed, the lines of incision being similar to those employed in Malgaigne's operation (Fig. 260); each of these flaps is left attached to the lip by a pedicle. The remainder of the outer edge of each cleft is freshened by removing the margins by a vertical cut. The flaps taken from the outer edge of the clefts are now applied to the horizontal wound surface of the central portion; the thin extremity of each flap is trimmed so as to meet in the middle line when the clefts are closed (Fig. 265). All tension is to be relieved by thoroughly freeing the lip and cheek from the bone.

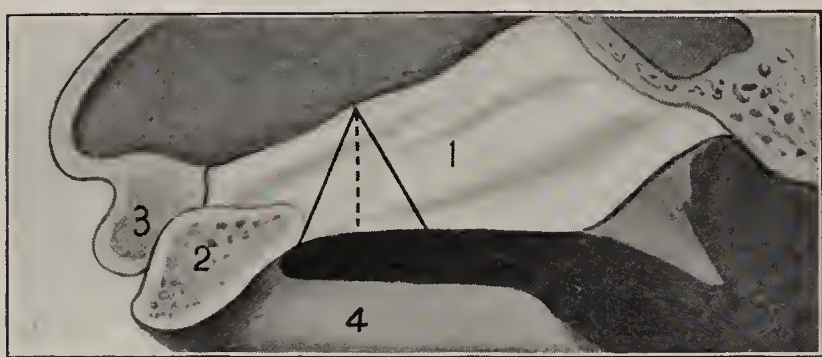


Fig. 264.—The Portion Included in the Solid Lines is Removed in Blandin's Operation. The Dotted Line Represents the Site of the Incision in Rose's Operation.
1, Vomer; 2, premaxillary bone; 3, upper lip; 4, alveolar process of upper jaw.

After-treatment of Harelip Cases.—The edges of the wound are to be thoroughly dried and penciled with a mixture of collodion and subiodid of bismuth. Or simple occasional cleansing may be employed. No further dressing is required. Strict attention on the part of the nurse is necessary to prevent the child from crying. The cavity of the mouth should be cleansed occasionally with a weak boric acid solution. Bits of absorbent cotton tied on a stick and dipped in the solution are best for this purpose. If the bowels do not move after the first day, a suitable purge should be given. The first defecations will be dark colored as a result of the blood swallowed.

A B

Fig. 265.—Operation for Double Harelip.
A, The incision; B, sutures introduced.

Removal of the Sutures.—The sutures should be removed at the end of a week. Union is usually found to be complete. If the union is only partial, the vermilion border, at least, is generally found to be united; the remainder of the cleft will unite by granulation, which may be assisted by strapping with adhesive plaster. In case of complete failure a second operation should be performed after from four to six weeks.

Hemorrhage is the chief danger from the operative procedure itself. Bronchopneumonia constitutes the chief after-danger.

Congenital Fissure of the Cheek.—This is observed (1) as a vertical cleft; (2) as a horizontal cleft; (3) as an angular fissure.

Vertical fissure arises either from defective union or from total failure of one lateral plate to join the midfrontal process. In the most aggravated cases the fissure reaches to the lower eyelid, constituting one of the forms of **coloboma palpebrae,** the conjunctiva being connected with the mucous membrane

Fig. 266.—Fissure of the Cheek, Fissure of the Upper Eyelid, and Auricular Appendages.

of the edges of the cheek cleft and through the latter with that of the enlarged oral orifice. The cleft may continue through the upper eyelid to the forehead or it may be connected with the nasal cavity.

Horizontal fissure of the cheek is the result of a failure on the part of the edges of the highest branchial arch to unite. An enormous enlargement of the mouth (**macrostoma**) is formed; the mouth may reach from ear to ear. Skin appendices in front of the auricle are sometimes seen in connection with this deformity (Fig. 266).

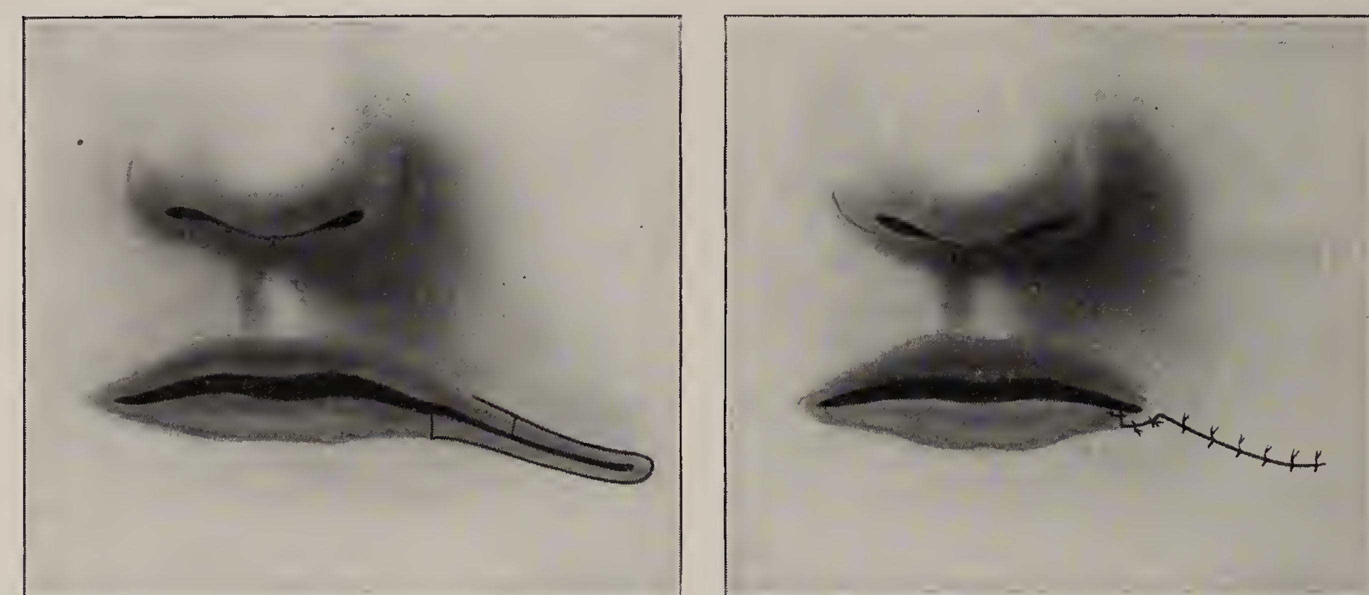
Angular fissure is sometimes observed. Ferguson records an instance in which the cleft extended from the left angle of the mouth to the base of the lower jaw. It occurs occasionally on both sides and simultaneously with other cleft deformities, as well as with congenital hypertrophy of the tongue (**macroglossia**).

Exceptionally the edges of the cleft appear in fissure of the cheek as scar

tissue. In the majority of instances of the deformity the angle of the cleft is attached to the gums by a connecting bridge or frenum; more rarely to the hard palate.

Treatment.—The edges of the fissure are to be freshened and the opposing surfaces brought together and united by sutures. In the case of horizontal cheek clefts with macroglossia the vermilion border of the cleft is to be dissected loose throughout its entire length, the incision commencing at a point on the upper lip where the angle of the mouth should be, and terminating on the lower lip about one-eighth of an inch nearer the median line than the above point (Fig. 267, A). The strip is then released by cutting directly upward through the lower lip, when it is shortened sufficiently to allow accurate adjustment in the formation of a new angle of the mouth. The strip is now secured in position with fine silk sutures and the gap in the cheek sutured (Fig. 267, B).

Congenital Anomalies of the Eyelids.—Complete absence of the eyelid is of rare occurrence. Imperfect development of the lid resulting in a fissure (**coloboma**) is occasionally observed. In some instances the entire thickness of



A B

Fig. 267.—The Operation for Cleft Cheek and Macrostoma.
The vermilion strip is sutured in position and the gap in the cheek closed.

the lid is wanting (Fig. 266), while in others a membranous intermediate portion occupies a part or all of the gap in the lid. Both the upper and the lower lid on one or both sides may be affected, or both upper lids or the upper lid of one eye may be involved. Coloboma of the eyelids may exist alone or it may occur in conjunction with other malformations of the eye, harelip, and clefts of the cheek, nose, hard and soft palate, and pharynx.

The **treatment** consists in paring the edges of the fissure and uniting the freshened surface by sutures.

Congenital Fistulas.—These are observed in the face, on the bridge of the nose, in the median line, at the lower extremity of the nasal septum, on the lower lip, in front of the ear, and behind the lobe of the ear. They can usually be traced with a fine probe for a distance of from half to three-fourths of an inch beneath the skin, the fistula apparently terminating in a cavity. They may lead from the nose to the base of the skull (Cruvelhier, Klebs); from the termination of the nasal septum to the nasal cavity (Ruysch); or from just behind the ear to the cavity of the mouth (Rose). The entire

fistulous track may be lined with epidermis (B e e l y). Their place of exit on the skin is occasionally the seat of an intractable eczema.

When the canal beneath the skin can be accurately followed, extirpation is indicated. This may be facilitated by leaving a probe *in situ* while the dissection is being made.

Fistulas of the Lower Lip.—These are usually accompanied by a strongly prominent lower lip, on the vermilion border of which appear two shallow dimples. At the base of each of these near the median line the opening of a fistula is found, the size of the head of a pin, from which more or less watery salivalike fluid exudes. The canals diverge, as a rule, and can be followed by a probe a distance of from three-fourths of an inch to one and one-fourth inches, ending in a blind passage. At the lower portion of their course and in the thick part of the lip they approach the mucous membrane of the mouth. The fistulous opening is surrounded by muscular tissue, which becomes narrow, or gapes, with movements of the parts. A snout-shaped lip is sometimes formed by a downward and outward lengthening of the lip.

The condition may be associated with other facial deformities, notably harelip, as well as malformations in other and remote parts. Heredity likewise enters into the causation. Defective embryonal development of the furrows on either side of the intermaxillary or thin portion of the mandibular process, together with overgrowth of the latter in cases of snout-shaped projection of the lip, originates the deformity.

Should the prominent lip or persistent secretion demand it, a wedge-shaped portion including the fistulous canal may be excised.

Auricular Appendages.—Congenital tumors in front of the ear, varying in size from a lentil to a pea, are sometimes observed projecting above the surrounding level, the so-called auricular appendages (Fig. 266). These appear in some cases to be simply reduplications of the skin, while in others a decidedly cartilaginous structure is found in the interior. Occasionally they are attached by a narrow pedicle. They occur on one side, as well as symmetrically on both sides. Sometimes there is a simultaneous malformation of the external ear, in which case the appendages take on a larger form. They may be simply snipped off with the scissors. A small vessel may require the application of a suture.

Stomatoplastic Operations.—These operations differ from cheiloplasty in that they aim at correcting congenital mouth formation rather than replacement of parts lost by injury or disease. The conditions most frequently requiring their performance are (1) **macrostoma**; (2) **microstoma**; (3) **ectropion of the lips.**

Macrostoma.—In case of congenitally large mouth the plastic operation for forming a new angle of the mouth described in connection with horizontal fissure of the cheek (*vide supra*) is to be preferred to the usual procedure of freshening the edges of the angle of the mouth and uniting the same by suturing. There is usually no tension on the parts and union is rapid and complete.

Microstoma is seldom congenital. Its most common cause is cicatricial contraction of the mouth following disease or injury. It is corrected by making an incision for the necessary distance beyond the angle of the mouth and lining this with mucous membrane from the cheek, which is loosened for this purpose. In order to prevent the incision from granulating together from

the angle inward toward the median line, the incision is prolonged as a Y placed horizontally at the angle and the mucous membrane of the cheek loosened more extensively at this point. The triangular-shaped flap of mucous membrane is sewed to the new angle. Or the older method of Rudtorffer may be tried. This consists in perforating the cheek at the point where the new angle is to be formed, and passing through the opening a metallic wire. When cicatrization of the opening is complete, the usual incision is made from this point to the already existing oral opening and covered with mucous membrane after Dieffenbach's method. The difficulty in obtaining cicatrization of the opening through which the wires are passed constitutes the chief objection to this method. The patient wears an oval double-faced ring, made of hard rubber, for an hour or more each day in order to prevent recontraction.

Ectropion of the lips, or eversion from cicatricial contraction of the mucous membrane lining the lip, in its complex forms is to be corrected by V-shaped excision of the cicatrix and Y-shaped union of the gap (*vide infra*). In other and more severe cases cheiloplastic procedures are indicated. Separating the labial edges from the cicatricial tissue, raising them to the proper level and filling the gap by a flap with a pedicle, will prove successful in a certain number of cases.

Meloplastic Operations.—Operations designed to correct defects in the soft parts of the cheeks are less frequently required than plastic operations in other portions of the face. The skin of the temporal region and of the forehead is most frequently utilized for this purpose, where the loss of substance is complete.

Schimmelbusch's operation is to be employed after removal of the entire cheek. The first flap is reflected upward from the neck, and, when in position, its skin surface replaces the buccal mucous membrane. The second flap is taken from the scalp, and, when turned downward, its raw surface is presented to the raw surface of the first flap, its outer hairy surface replacing the beard. The pedicles are divided in four weeks.

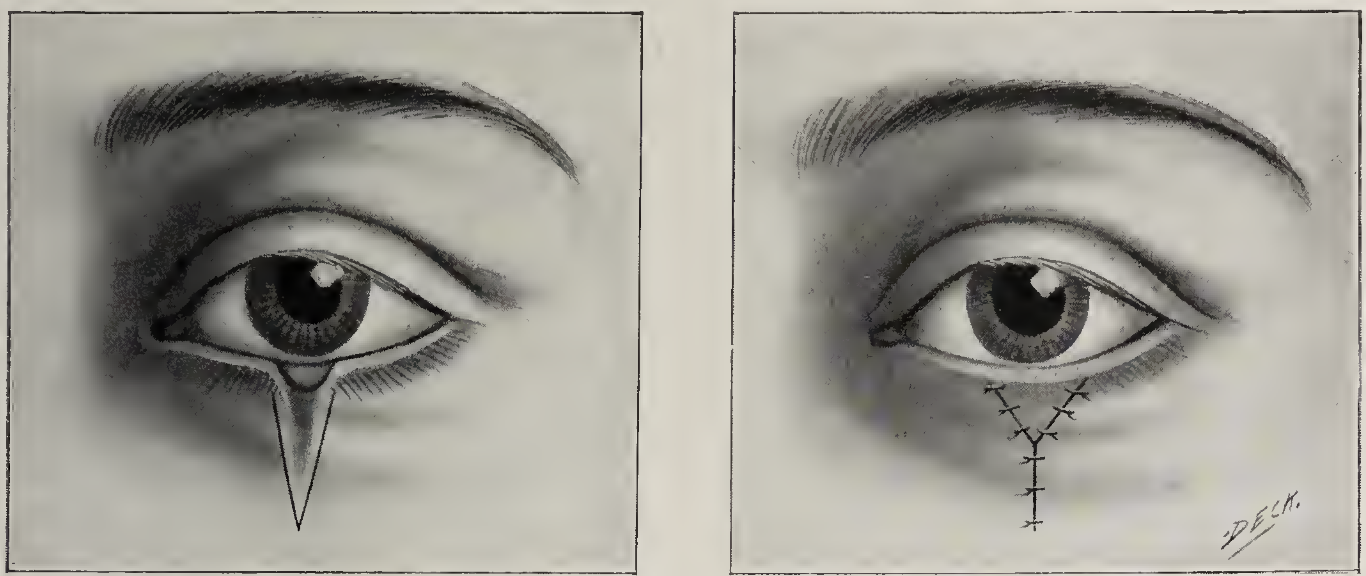
In partial defects flaps with small pedicles are successfully employed on account of the rich blood-supply. When in the extirpation of a growth the mucous membrane cannot be spared, this structure is not easily replaced; the buccal surface of a skin flap is likely to undergo cicatricial contraction.

In **cicatricial lockjaw** following noma the cicatrix must be divided, and, in order to prevent recontraction, the defect filled with double skin flaps, one integumentary surface facing the buccal cavity and the other presenting externally (Gussenbauer).

Blepharoplastic Operations.—Cicatricial deformities of the eyelids constitute the most frequent indication for these operations; they are sometimes resorted to after the extirpation of morbid growths. **Ectropion,** or a turning outward of the lid, is the most common of these; the lower lid is most frequently affected. A condition of **entropion** attends cicatricial contraction of the conjunctival surface of the lids.

The first step in the correction of ectropion is the separation of the everted conjunctiva from the underlying cicatricial tissue. The edge of the eyelid is then restored to its normal position. In partial ectropion a simple V-shaped incision made by dissecting up the triangular-shaped flap, sliding it in an

upward direction, and suturing this so as to form a Y-shaped line of union, after restoration of the lid to the proper level, suffices (Fig. 268). Complete ectro-



A B

Fig. 268.—Operation for Simple Ectropion.
A, The incision; B, the Y-shaped line of union.

pion is best remedied by making the incision along the tarsal margin, dissecting the conjunctiva loose, restoring the edge of the lid to the proper level, and supplying the then existing defect by a flap from the temporal regions (Fig. 269). The transplanted portion must be at least twice as large as the defect to be corrected. The use of Reverdin transplanted flaps or the method of Thiersch likewise gives good results. All methods are followed by slight relapses in a certain proportion of cases. These are to be corrected by subsequent, though less formidable, operations. In ectropion of the upper lid the same procedures suffice, the lines of the incision being reversed.

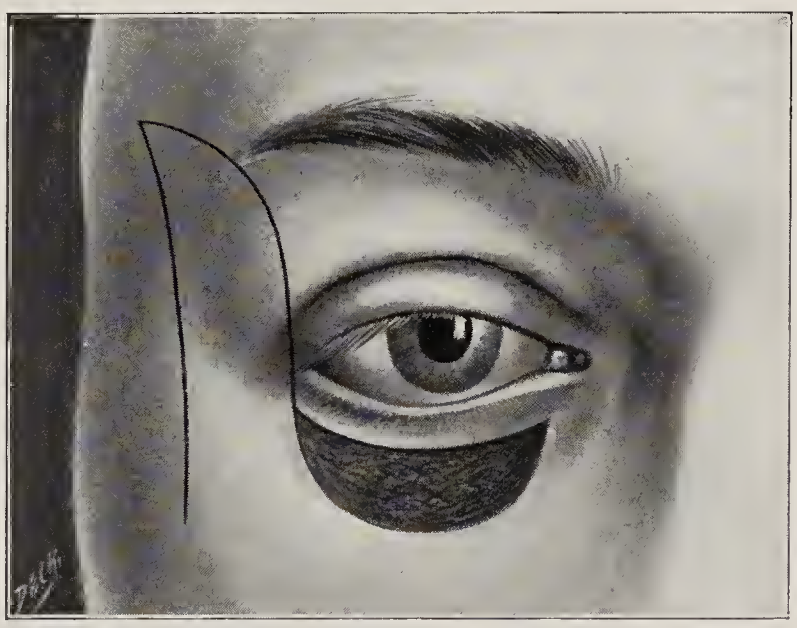


Fig. 269.—Fricke's Method of Blepharoplasty.

Ectropion of both lids is sometimes treated by tarsorrhaphy, the lids being sewed together over the globe after correction of the defects, until complete healing has taken place.

THE SOFT PARTS OF THE NOSE AND NASAL CAVITIES

The only injuries of the soft parts of the nose requiring special notice are those which involve the alae. Portions of the latter, though entirely separated, should be at once replaced after careful cleansing; they occasionally unite, even some hours after the injury. If they fail to do so, certain plastic operations are indicated.

Fractures of the Nasal Bones.—These are always the result of direct

violence. The fragments are displaced in the direction of the nasal cavity. These, if permitted to remain, lead to a saddle-shaped deformity of the organ. In addition to the cosmetic effects, certain functional disturbances, such as embarrassment of respiration, loss of sense of smell, etc., follow. The indications, therefore, are to replace the fragments as soon as possible. This is best accomplished by a pair of dressing forceps introduced in the nostril, first on one side and then on the other, the fragments on the outside being supported with the thumb and finger of the other hand. By pressure made upward the displaced fragments are forced into position. The septum, if displaced, is to be straightened forcibly by grasping it with the dressing forceps and making pressure in the proper direction. Retention of the fragments, after reduction, sometimes requires nothing more than simple packing of the nostril with antiseptic gauze. This sometimes produces so much irritation as to lead to its abandonment. The best expedient, if spontaneous retention does not occur, is to pass a needle, grasped in a stout forceps, by drilling movements through the fragments from side to side. A narrow piece of adhesive plaster is now passed over the bridge of the nose and made to include the two ends of the needle. The latter may be withdrawn at the end of a week or ten days (Mason).

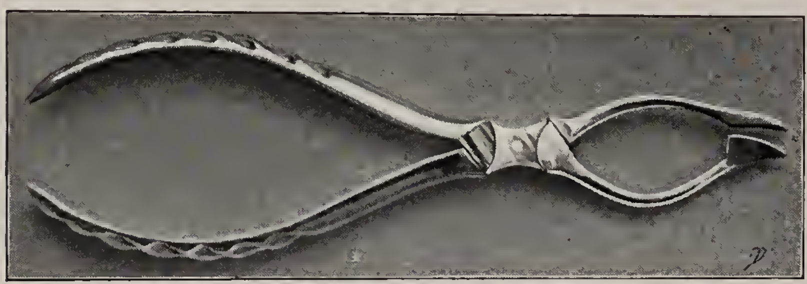


Fig. 270.—Asch's Open Scissors.

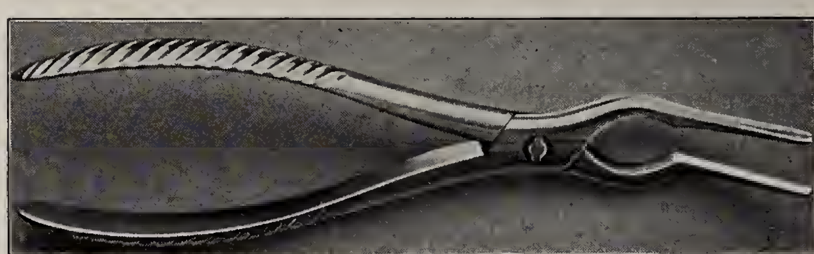


Fig. 271.—Compression Forceps for Straightening the Septum.

Sometimes as a result of traumatism, but more frequently from abnormalities of growth (Harrison Allen), **deviations of the septum** are observed. The deviation may affect the cartilaginous septum alone, or the vomer may likewise be involved. No difficulty should be experienced in diagnosing these deformities; only the most superficial observation could possibly mistake them for new growths.

Fig. 272.—Asch's Vulcanized Tube Splint.

The treatment consists in thoroughly dividing all adhesions to the turbinates, and making two intersecting incisions at the point of greatest convexity of the deformed septum by means of the open scissors (Asch, Fig. 270). The finger is then introduced into the obstructed side and the four segments of cartilage made by the intersecting incisions broken at their bases by forcing them into the concavity. The septum is then straightened by powerful compression forceps (Fig. 271) and a snugly fitting vulcanized tube splint (Fig. 272). In case the vomer is primarily at fault, this may be corrected by dissecting the upper lip from the alveolar side and detaching the anterior portion of the vomer with the attached cartilaginous septum from the superior maxillary bone by means

of the bone-cutting forceps. The entire septum is then crowded over to its normal position and there maintained by the suitable packing of the formerly narrowed nares (L o s s e n).

Epistaxis.—This may occur from external injuries or from injuries of a vessel frequently found at the anterior portion of the cartilaginous septum, which is easily invaded by forcible attempts to remove crusts from the nasal cavity. Acute and chronic inflammatory conditions, ulcerative conditions of the mucous membrane, tumors, etc., and finally defective cardiac action, as well as hemophilia and the beginning of typhoid fever, give rise to alarming hemorrhages.

The **treatment** consists in the application of cold, either externally by means of ice over the bridge of the nose, or the use of ice-water snuffed up the nose or injected by means of a syringe. In mild cases deep inspirations will sometimes suffice to arrest the bleeding. By this means the mucous membrane is emptied of its blood by aspiration, and at the same time the blood which has escaped from the vessel is forced against the open point and coagulation favored. This failing, plugging of the anterior nares with nonabsorbent cotton is the next step to be taken. These plugs should be forced as deeply as possible into the nasal cavity by a screwing movement. Hemorrhage may now persist from the posterior nares, in which case it will be necessary to resort to the plugging of both posterior and anterior nares. This may be accomplished, in case of emergency, by the use of a soft-rubber catheter, which is passed through the anterior nares, grasped with a pair of forceps as it emerges from behind the uvula, after which it is drawn over the back of the tongue and thence out of the mouth. Here a doubled strand of strong thread about a foot long is tied to it. In the middle of this, a firm wad of common cotton (nonabsorbent) is tied. The catheter is now withdrawn by drawing on the end projecting from the anterior nares, the forefinger of the left hand at the same time guiding the cotton plug attached to the string over the base of the tongue and up behind the uvula until it is safely lodged crosswise, at the posterior nares. The end projecting from the mouth is permitted to remain for the purpose of withdrawing the plug when necessary. The double strand which projects from the anterior nares is separated, a tightly rolled wad of cotton placed outside the nose and between the strands, and the latter tied over this, to serve as a plug to the anterior nares. If a B e l l o c q ' s cannula is at hand, this may be advantageously employed (Fig. 273).

Rubber balloons, on the principle of B a r n e s ' s uterine dilators, have been suggested, these being filled with air or ice-water, after introduction. Passing a fold of gauze or linen, covered with vaselin, well into the nasal cavity and packing this with cotton, answers as well, and can be improvised in cases where this would suffice.

Rhinoscopy.—Inspection of the nasal cavities is required for the exact diagnosis of foreign bodies, acute and chronic inflammatory conditions, and tumors. In order to accomplish this the parts must be dilated and illuminated. Direct inspection through the nostrils in front is called **anterior rhinoscopy** ; where a mirror is placed in the fauces and rays of light are reflected on this, illuminating the parts and at the same time reflecting their image in the mirror, the manipulation is known as **posterior rhinoscopy.**

Anterior rhinoscopy is made by dilating the flexible portions of the nostrils by means of a suitable speculum, and illuminating the cavity by means of light reflected from the surface of a concave mirror. A convenient form of self-retaining speculum for this purpose is shown in Fig. 274. Forcible

Fig. 273.—Bellocq's Cannula with the Spring Carrier Projected.

elevation of the tip of the nose, in conjunction with the use of the speculum, permits accurate inspection. Turning the patient's head from side to side will facilitate the examination of the different parts.

Posterior Rhinoscopy.—This is more difficult than the anterior method.

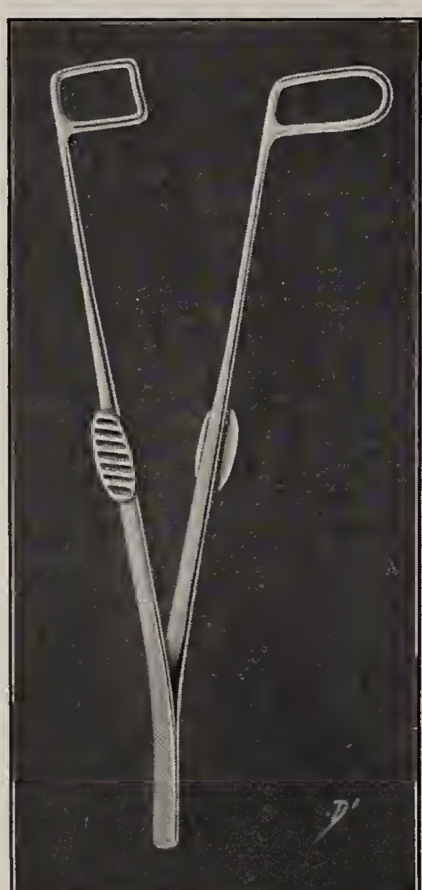


Fig. 274.—Self-retaining Nasal Speculum.

Fig. 275.—Nasal Electric Light Speculum.

A mirror is placed in the pharynx, from which light is reflected into the posterior nares; the palate must remain completely relaxed and the tongue depressed. The palate can sometimes be controlled by the patient if he is directed to say "Eh" with a strong nasal sound. If after a few patient trials

the uvula is still found to be irritable and disposed to drag up forcibly against the surface of the mirror, the parts may be anesthetized with an application of a 10 or 20 per cent solution of cocain. Before resorting to this, which is very disagreeable to the patient, an attempt may be made to steady the

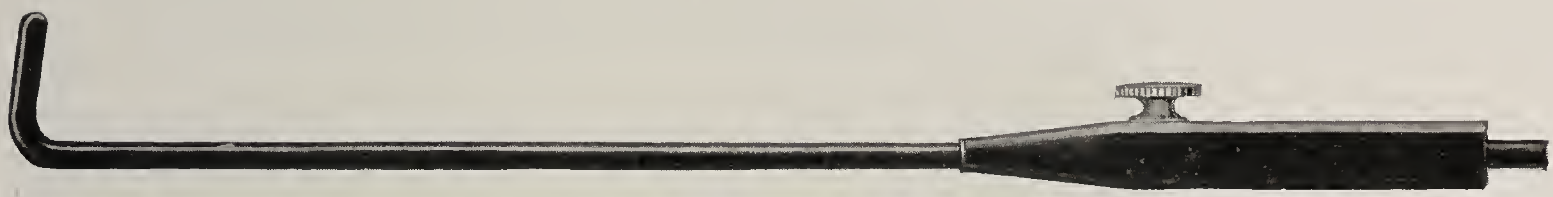


Fig. 276.—French's Palate Hook.

soft palate by means of a palate hook. The most efficient of these hooks is that devised by Dr. T. R. French (Fig. 276). The tongue is to be kept out of the way by means of a tongue depressor. In depressing the tongue care should be taken to drag it forward at the same time, rather than permit it to be forced back against the fauces; the latter produces gagging.

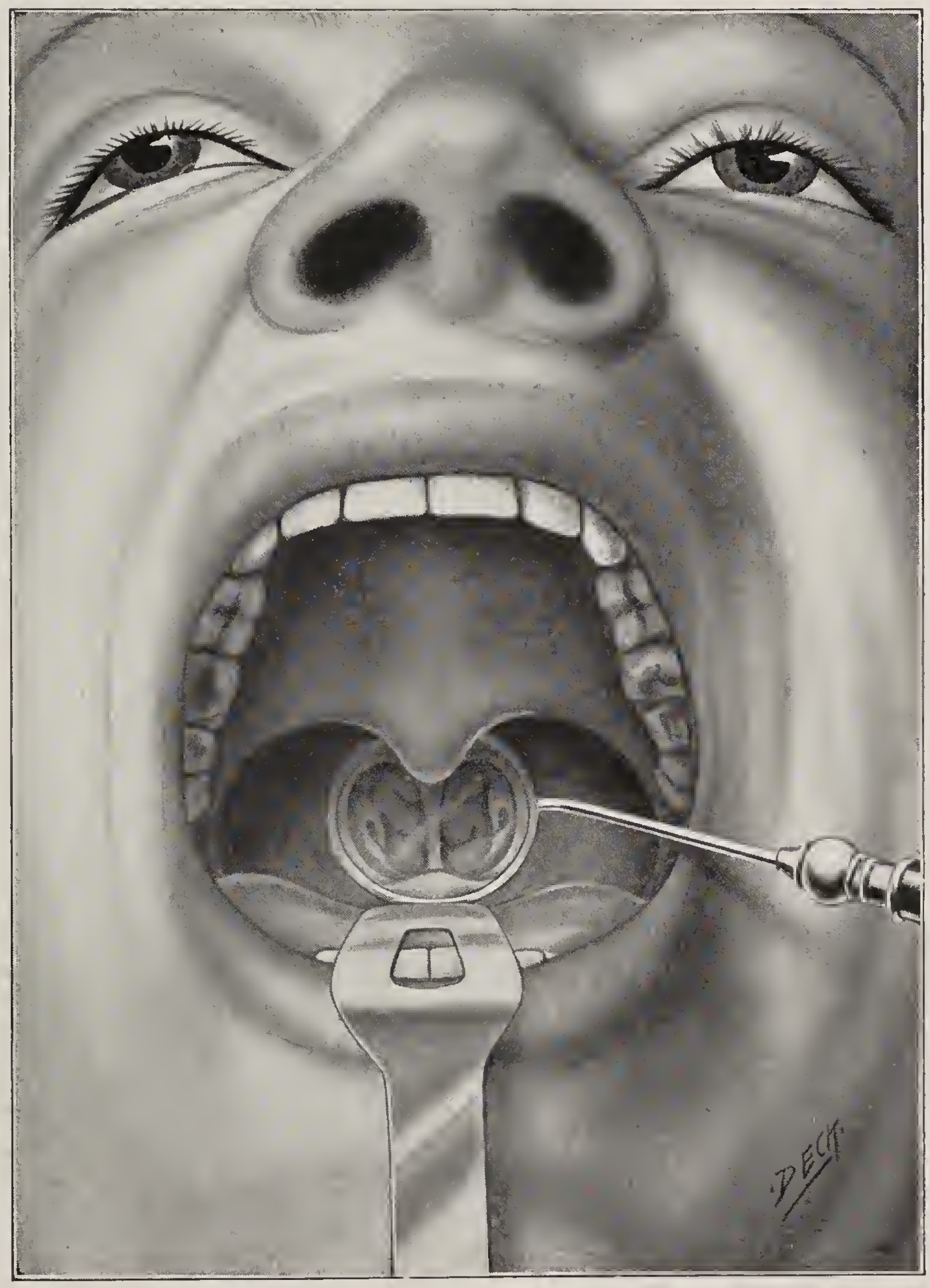


Fig. 277.—Posterior Rhinoscopic Examination.

In order to be able properly to diagnose morbid conditions about the posterior nares, the surgeon should familiarize himself with the appearances of the parts in health (Figs. 277, 278).

Foreign Bodies in the Nose.—A foreign body in the nose is of rather common occurrence among children, as the result of either mischief or accident. In the act of vomiting, portions of the contents of the stomach find their way into the nose through the posterior nares. Soft articles of food in this locality are easily expelled; the stones of fruit which have been swallowed, or other ingested articles, however, may give rise to considerable irritation. Children often place beans, peas, and buttons in the nose, in play, though anxious mothers sometimes imagine that their children have placed a button or some other foreign body in the nose when this is not really the case.

The presence of a foreign body in the nose at once produces a more or less profuse seromucous discharge; this soon becomes mucopurulent or even bloody if ulceration results.

The diagnosis should be made between foreign body producing irritation and ulceration and syphilitic nasal disease. Carcinoma and sarcoma may give rise to the same symptoms. The escape of flocculent or cheesy masses with the discharge is characteristic of foreign body (Bosworth). When ulceration is present, it is neither progressive nor extensive; necrosis is very rare. If the foreign body is well forward it may produce deformity. Instrumental examination should be preceded by cocain anesthesia. A thorough preliminary washing of the nasal fossae with a mild alkaline solution will enhance the anesthetic effects of the cocain. Chloroform may be administered to young children. The probe will usually detect readily the presence of the foreign body. Previous unsuccessful attempts to remove the foreign body may have denuded the turbinated bones of their coverings. The probe coming in contact with bare bone may mislead the surgeon. Inspection by anterior rhinoscopy may assist.

Fig. 278.—Rhinoscopic Image. The illustration is shown larger than normal in order to bring out the parts in detail.

The treatment is very simple. An ordinary wire curet of the proper size will serve to dislodge almost any foreign body that can be crowded into the nose (Fig. 279). This may sometimes be improvised from an ordinary hairpin. If directly within reach, the foreign body may be grasped with a pair of forceps. If lodged far back, a finger passed from the pharynx into the posterior nares will assist in steadying the object while it is being extracted with the loop of the curet.

Inflammation and Tumors of the Covering of the Nose.—The presence of short connective-tissue fibers between the skin and the periosteum and perichondrium of the nose is unfavorable to the development of phlegmonous inflammation of the nasal covering. **Erysipelas,** however, develops readily; the broad follicles with open mouths favor acne and pustulous affections and the infection of erysipelas enters and extends rapidly.

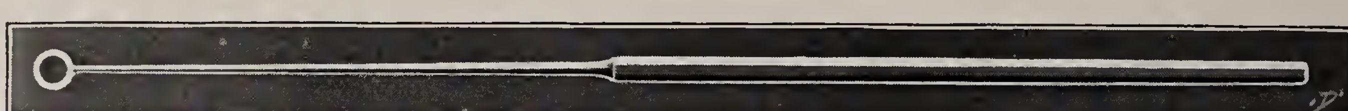


Fig. 279.—Small Wire Curet.

Acne rosacea is a hyperplastic process, consisting of a proliferation of the skin tissue, with development of blood-vessels. It is generally a bright red or bluish color. Unequal development leads to a wartlike or uneven appearance in some cases. It is popularly associated with the abuse of alcoholic stimulants, though it does not necessarily arise from this cause. It occurs more particularly in middle age and late in life. Removing the skin from the entire nose and replacing this by Thiersch's skin transplantation,

or permitting the space to fill up with granulation tissue, though a severe remedy, is the only resource in the most severe cases. Fusiform excision frequently repeated, and the suturing of the edges of the gaps, may be resorted to in less severe cases. Solutions of the aqueous extract of ergot and carbolic acid (aqueous extract of ergot, 1; distilled water, 10; carbolic acid, 10) injected in small quantities into the skin and beneath its surface have been used with some success (Riesmyer).

Lupus.—This commences in the hyperplastic granulating form and afterward passes more deeply, finally involving the cartilages, and ulcerating. It may spread over the entire surface of the organ, reach the nasal bones, and extend laterally to the nasal processes of the superior maxillary bones. The septum suffers in the general destruction and the tip of the nose becomes depressed in consequence. Excision and skin transplantation after Thiersch is the best remedy (see page 331).

Rhinoscleroma is a disease characterized by an extremely chronic inflammation of the coverings of the nose. The nasal mucous membrane, as well as that of the pharynx and larynx, may be involved. It sometimes produces great deformity. It is marked by the occurrence of hard grayish-red nodules covered with normal epidermis, the tissue of which is infiltrated with round cells. These are the sites of numerous large lymphatic vessels. Ulceration may occur in the large nodules. A specific bacillus has been shown to exist in the disease (Finch) and pure cultures of this microorganism have been obtained (Paltauf and Eisenberg). The disease has been produced in the lower animals by inoculation (Stepanow). Free excision, in the early stages, is the only remedy.

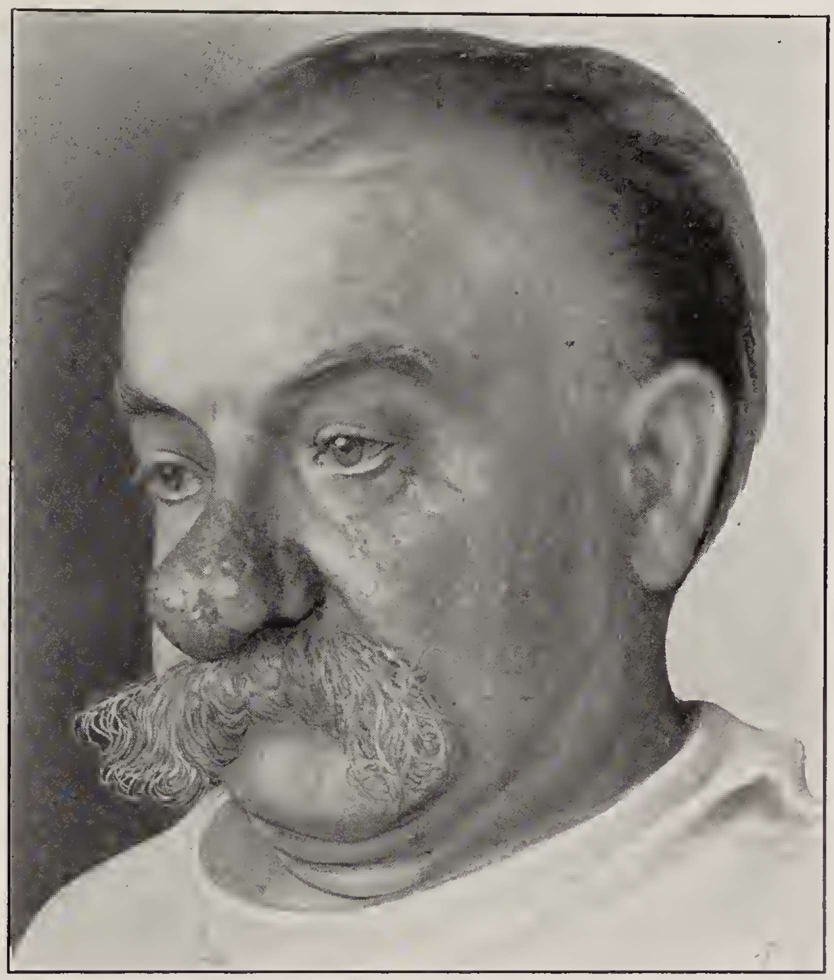


Fig. 280.—Rhinophyma, before Operation.

Rhinophyma.—This is a name applied to an elephantiasis-like thickening of the skin of the nose, in which all of its structures take part. Large soft nodules frequently appear on the alae nasi (Fig. 280). Distinct enchondromas have been found in this situation.

The **treatment** consists in reflecting the skin covering from the nodules and removing these, the skin flaps being afterward trimmed and replaced. The removal of V-shaped longitudinal strips the entire thickness of the skin serves to reduce the nose in size (Dieffenbach). In extreme cases the entire integumentary covering of the nose may be dissected away and its place supplied by Thiersch skin grafts. The result as shown in Fig. 281 was obtained by a combination of these methods.

Tumors of the covering of the nose occur in the shape of atheromas, fibromas, and adenomas of the sweat-glands. The most important tumor in this region, however, is **epithelial carcinoma.** The latter occurs usually as a flattened ulcer and differs from acne and lupus in selecting primarily by preference the alae of the nose. It is peculiar in that it rarely passes from one side to the other; as a rule, it extends outwardly and in an upward direction. It usually remains limited to the integument for a considerable time. The lymphatics become involved late in the affection; therefore early extirpation affords a favorable prognosis.

In addition to lupus and carcinoma, **syphilitic ulceration** and **destruction of the nose** may occur. In the differential diagnosis the history and the results of microscopic examination must here be the main reliance.

Inflammations of the Mucous Membrane of the Nose.—**Chronic hypertrophic rhinitis,** the thickening being particularly over the inferior turbinated bones, polypi, and ulceration may result from repeated attacks of catarrhal inflammation of the mucous membrane lining the nose. This inflammation may extend to the frontal sinuses (page 515) and to the antrum of Highmore (page 528).

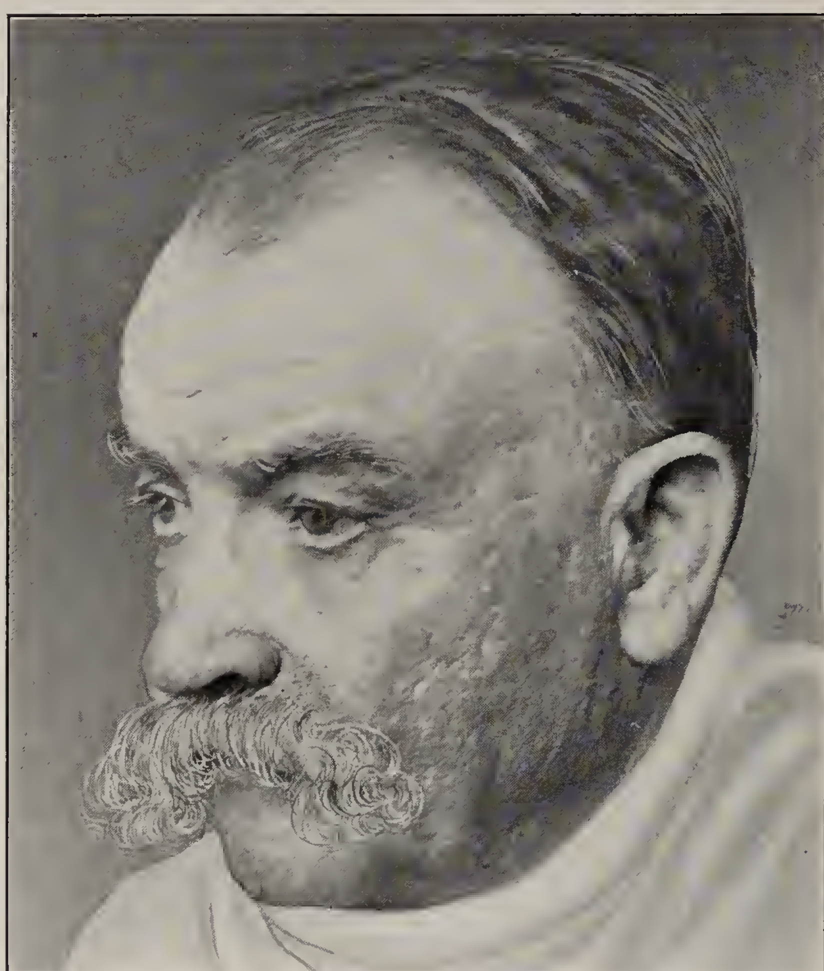


Fig. 281.—Rhinophyma. The Appearance Presented after Operation.

Ozena results from an abnormal secretion from the mucous glands, the peculiar characteristic of which is a tendency on the part of this secretion to undergo rapid putrefactive changes. It is not infrequently associated with **chronic atrophic rhinitis.** The nasal cavities are abnormally large in this affection, the nasopharyngeal region and orifices of the Eustachian tube being visible in exceptional instances. The disease may be preceded by the hypertrophic form. More or less impairment of hearing is associated with atrophic rhinitis in about two-thirds of all the cases. A **pharyngitis sicca** may be associated with ozena and atrophic rhinitis. In addition to the putrid odor, the characteristic feature of the affection is the presence of dried crusts on the mucous surface. This is also observed in pharyngitis sicca.

The **causes** of ozena are obscure. It occurs most frequently in so-called scrofulous subjects. Syphilitic disease of the nose should not be confounded with it. Here there is a puriform discharge with putrid odor, rather than a putrefaction of the secretion combined with the accumulation of crusts. The pressure arising from these crusts, as the secretions dry on the surface of the mucous membrane, is said to give rise to disturbances of the circulation in the parts and consequent atrophy (Bosworth).

The **treatment** consists in a thorough removal of the crusts; spraying or syringing the mucous membrane with a cleansing alkaline and antiseptic solution, such as bicarbonate of soda, gr. ij; borate of soda, gr. ij; carbolic acid, gr. ij; glycerin, dr. ij; water, oz. j (Dobell); this is followed by such applications as will stimulate the secretion of mucus. Of these may be mentioned a 0.5 per cent solution of salicylic acid; a 2 per cent solution of chlorate of potash, or a pledget of cotton saturated with a 20 per cent solution of chlorid of zinc to which sufficient hydrochloric acid has been added to make a clear liquid. In case difficulty is experienced in loosening the crusts by means of the spray apparatus, pledgets of cotton, upon a probe and saturated with the cleansing agent, are to be passed through the nasal cavities to effect their dislodgment.

The daily application of simple cotton plugs, to excite the secretion of mucus, has been advocated (Gottstein). These may be combined with stimulating medicaments by incorporating certain powders in the cotton (Woakes). Iodol, boric acid, or aluminum acetotartrate are very useful, applied in this manner. The treatment, however, involves considerable discomfort to the patient.

Ulceration of the mucous membrane frequently results from acute and chronic rhinitis and from too persistent efforts to dislodge dried secretions. These frequently show but slight disposition to heal. By resisting the temptation to remove the crusts frequently, and occasionally applying white precipitate ointment, or oxid of zinc ointment, the healing process is soon completed. **Syphilitic rhinitis in the newborn** may be associated with ulceration. This differs from that resulting from the common form of rhinitis in that the syphilitic form is associated with periostitis and perichondritis as well, which can be demonstrated by palpation from without, the external osseous covering also being involved. The treatment is that of congenital syphilis in general, namely, appropriate doses of gray powder or inunction of blue ointment. Syphilitic affections of the nose will be discussed on page 508.

The ulceration of **farcy** or **glanders** sometimes occurs in the nose; it is very frequently fatal. It is usually multiple, occupies both nares, and is accompanied by swelling of the skin of the face and scalp, with marked infiltration of the subcutaneous cellular tissue. The occurrence of these symptoms in conjunction with high fever and the presence of suppurative ulceration of the nares should always excite suspicion of farcy. Bacteriologic examination will assist in the diagnosis (see page 32). It is suggested, in case the diagnosis can be made sufficiently early, to expose the nasal cavities by means of Bruns's osteoplastic resection (page 507) and arrest the propagation of the infection by the application of the actual cautery.

Tumors of the Mucous Membrane of the Nose.—Tumors which spring essentially from the nasal mucous membrane are comprised in the classes known as **mucous polypi, papilloma,** and the rarely encountered **epithelioma** and **fibrosarcoma.** Tumors which invade the nasal cavity from other regions will be considered in connection with the surgery of those regions (tumors of the upper jaw, of the pterygopalatine fossa, and of the base of the skull).

The **mucous polypi** are the most frequently seen of all tumor formations of the nose. They result from repeated attacks of rhinitis; they have also been observed in connection with tumors springing from the upper jaw and the base of the skull.

Mucous polypi are of a soft consistency, almost gelatinous at times, and a pale grayish-yellow color, not unlike the ocean polypi. Microscopically they consist of a development of the mucous glands and submucous connective tissue; the cells are few in number and are surrounded by an almost homogeneous matrix. Pathologically, they are benign adenomyxomas of the mucous membrane. The great majority of these tumors take their origin from the mucous membrane covering the turbinated bones, particularly the middle and nasal meatus. Less frequently they originate from the free posterior edge of the septum and hang down behind the soft palate. Rarely they are found to spring from the mucous membrane covering of the ethmoid bone. Their growth, except in the case of those at the posterior edge of the septum, tends at first to bring them forward toward the anterior nares. Subsequently, they grow posteriorly and may even appear at the posterior nares or in the pharyngeal cavity. In this location a digital examination will reveal their presence. The anterior extremity of a polypus, if well forward in the nasal cavity, is prone to ulceration. As a result of constant irritation and chronic inflammatory action, the tumor may become more or less indurated and thickened. Under these circumstances, also, hemorrhage is of occasional occurrence.

Mouth-breathing results from an occlusion of the nostrils from the presence of polypi, and as a result of chronic thickenings. This, in its turn, may lead to diseases of the pharynx, larynx, bronchi, and lungs. Asthmatic troubles are also, in some instances, traceable to intranasal disease. The sense of smell is weakened and the formation of vowel sounds greatly impaired; to the latter, a nasal sound is added. Large polypi occupying both nasal cavities may produce marked deformity of the face. In the **diagnosis of polypi** care must be taken not to mistake for these growths the chronic hypertrophic conditions of the mucous membrane covering the turbinated bones, particularly that covering the anterior edge of the inferior turbinated bone. The grayish color of the latter compared with the bright red color of the former, together with the fact that polypi are usually more or less pedunculated while simple hypertrophies are sessile, will serve to distinguish the one from the other.

Papilloma is a comparatively rare affection of the mucous membrane. It consists of a warty growth, situated, in the case of the soft variety, which is the more common on the inferior turbinated bone; the hard papilloma occurs near the mucocutaneous junction and may spring from the septum, floor, or inner surface of the ala. It is usually sessile in character. It gives rise to no particular disturbance until it has attained a considerable size. Hemorrhage may occur if erosion of the growth takes place. The **treatment** consists in extirpation with the cold snare, with or without the application of the galvanocautery to the base. In case of very large papilloma an external operation (Ward, Verneuil), such as temporary resection of the nose (Bruns, page 507), may be necessary.

The Operative Treatment of Nasal Polypi.—The only successful means of dealing with these growths is their extirpation. The use of the forceps for this purpose has now very largely given way to that of the cold wire snare écraseur, Jarvis (Fig. 282). This, or one of its modifications, is mounted with fine unannealed steel piano wire, which gives it a certain amount of stiffness and enables the operator after a little practice, to place the loop in any desired location or position. This being accomplished, the encircled portion of the

tumor is severed from its attachment. Instruments designed to accomplish the tightening of the loop with but a single movement of one hand are preferable. The galvanocautery loop (Middeldorpf and Voltolini is now seldom used by operators of experience. This cauterization, as well as the barbarous procedure, formerly practised, of removal of a portion of the turbinated bone attached to the growth, is unnecessary.

Cocain anesthesia should always precede the operation for removal of polypi. A freshly made 20 per cent solution, thrown into the nose by means of a spray apparatus, should be used; this produces insensibility both rapidly and completely. Large growths are difficult to cocainize, but by persisting, anesthetization may be finally accomplished. A portion of the growth being removed, a fresh supply of the cocain solution should be introduced. It is not always possible to encircle the entire growth at the first attempt. The loop should be passed between the septum and the growth with its lower border below the level of the tumor, when it should be turned to a horizontal position (inasmuch as in the great majority of cases the growth is attached to the middle turbinated bone), and by gentle manipulation slipped in an upward direction until as much of the growth as it is possible to grasp is judged to be within its opening. The loop should now be forcibly tightened, the instrument being held steadily; the process is really a cutting one. If an exostosis of the septum pre-

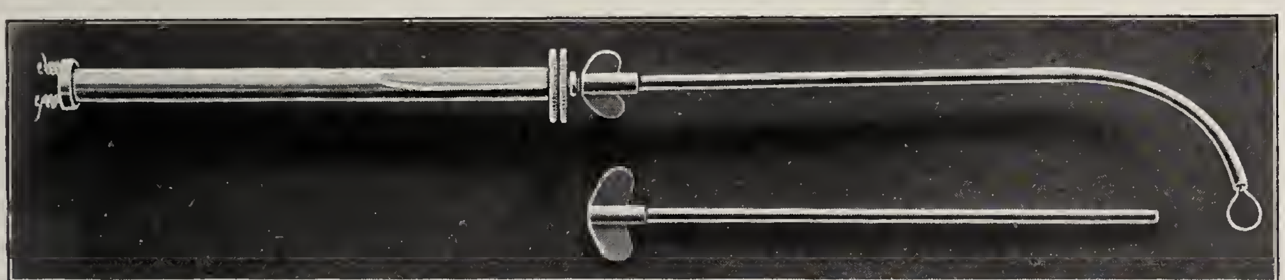


Fig. 282.—Jarvis's Snare.

vents the proper introduction of the wire loop, this should be removed (*vide infra*). Several sittings, as a rule, are necessary, and in order to guard against further growth the case should be kept under observation for several months.

Osteoma.—While it is not a specially rare occurrence for bony tumors that have their origin in other parts to invade the nasal cavity, a growth of this nature occurring primarily in the latter region is of infrequent occurrence. These tumors are among the nasal growths first described by the earliest writers on medicine. Their etiology is obscure. They occur early in life, say from the age of fifteen to twenty; a case making its first appearance at forty-five is recorded, however (Tillmanns). The male sex seems to be attacked by preference.

External deformity is usually noticed before the occurrence of nasal stenosis, owing to the fact that the osseous growth has its origin in the upper portion of the nasal cavity, and extends toward the face rather than in a downward direction toward the lower meatus. The orbit may be invaded, the tumor extending through the ethmoid cells. Pain may be present, due, in great part at least, to pressure on some of the sensory nerves. Epistaxis is not of frequent occurrence. Any discharges from the nose that take place are due to ulceration or necrotic changes in the tumor. The latter may lead to external fistulous openings.

These growths have their origin in the periosteum and generally spring from one of the accessory sinuses. The ethmoid cells give rise to them in the majority of instances, though they may spring from the septum or inferior turbinated bones. Their surface is irregularly lobulated and covered with mucous membrane. Their external bony surface is compact, while the interior is composed of cancellous tissue.

The osteomas are sometimes distinguished as the hard and the soft variety, though this division is misleading from the fact that they are all hard to the touch. The division is based on the relative amount of compact and cancellous tissue which goes to make up the tumor. Osteoma can be mistaken only for osteosarcoma. The history of the growth, and, in case of doubt, the removal of a portion for microscopic examination, will determine the question.

The **treatment** consists in extirpation. An external operation, in order to reach the place of attachment of the growth, will usually be necessary (*vide infra*). This must be planned in accordance with the demands of individual cases. Osteomas, attached to the septum or inferior turbinated bone, may occasionally be reached and removed by means of the nasal saw without external operation.

Fig. 283.—Skin Incision for Splitting the Nose.

Enchondroma.—This is a very rare affection, if the term is restricted, as it should be, to the large, round, nodulated tumor which presents all the clinical features of fibroma, but which on removal is found to contain hyaline cartilage. The nasal cavities do not present favorable conditions for the development of cartilaginous tissue. The symptoms are such as are met with in fibroma, namely, nasal stenosis and mucopurulent discharge; the latter may be offensive as the result of retention. The slow growth of enchondromas, their great density, immobility, pinkish-yellow color, and nodulated appearance, together with their location, which is usually the point of junction of the septum with one of the alar cartilages, serve to distinguish them from the nasal growths and from deviations of the septum. They usually occur in young subjects.

The method of removal is to be determined by the size and situation of the growth. Either the cold snare, the curet, or the gouge may be employed. They show no tendency to recurrence.

Osteoplastic Resection of the Nose.—The complete removal of intranasal tumors may demand the exposure of these, together with the nasal

cavities, through an external operation. The simplest of these operations consists in splitting the nose in the median line (Fig. 283), from one or the other nasal orifice to the nasal bones. Though the deformity following this operation is not great, it does not give access to any point beyond the anterior nasal fossae.

Fig. 284.—Langenbeck's Line of Incision for Osteoplastic Resection of the Nose.

Langenbeck's operation consists of a temporary resection of the bony lateral wall of the nose. The incision is commenced in the median line slightly above the root of the nose and is carried directly downward in the median line, reaching to the ala. Another incision, commencing at the inner cavities of the eye and extending downward, parallel to the first and corresponding to the posterior border of the nasal bone, likewise extends to the ala nasi. These two incisions are joined by a horizontal one at their lower extremities (Fig. 284). By means of a pair of bone-cutting forceps the bone is divided along the vertical lines of incision and the osteocutaneous flap turned upward.

Ollier's Operation.—The design in this operation is to detach the bony framework of the nose from the face and turn it downward. Two incisions, one on each side of the nose and at its junction with the cheek, are made. These extend to the alae of the nose. A slightly curved transverse incision connects them above (Fig. 285). By means of a thin-bladed narrow saw, section of the bone and septum is made along the same lines. The nose, thus freed from its attachments, is tilted downward on the face. This operation gives access to the nasal cavities and nasopharyngeal space.

Fig. 285.—Ollier's Line of Incision for Osteoplastic Resection of the Nose.

Bruns's Operation.—In this procedure the first incision is commenced immediately below the outer margin of the nostril on the sound side, and is carried in a horizontal line directly across to from half to three-fourths of an inch beyond the outer limit of the

other nostril. This is carried directly down to the bone, but does not invade the cavity of the mouth. A second horizontal incision is made across the bridge of the nose at its narrowest part, from one inner canthus to the other. These two incisions are joined by a third, vertically placed, at the junction of the nose and cheek (Fig. 286). A thin-bladed saw is now introduced at the point of commencement of the first incision and made to enter the nasal cavity. The first section made by the saw is through the anterior nasal spine and septum; the instrument is then carried around the entire extent of the original lines of incision. The free end of the saw plays in the nasal cavity throughout the entire extent of the section of bone; its tilted position makes a beveled cut. The bony section is confined entirely to the superior maxilla, the anterior portion of the inferior turbinated bone, and the bony septum, the latter being divided last from below upward by means of a pair of bone forceps. The entire nose is now turned to one side (Fig. 288).

Fig. 286.—The Line of Incision for Bruns's Osteoplastic Resection of the Nose.

The best of these operations is that of Bruns. It is comparatively easy of performance, and by means of it wide access is gained, not only to the nasal passages, but to the nasopharynx as well.

In all of the operations of osteoplastic resection of the nose, when the indications for which the operation was performed have been accomplished, the parts are restored to their normal position and there sutured.

The position of the head during these operations is of importance. That of Rose, with the head in a dependent position over the edge of the table, has some advantages (see page 534). Plugging the posterior nares, to prevent the blood from passing into the larynx, or preliminary tracheotomy and the use of Trendelenburg's cannula, may also be employed.

Fig. 287.—Osteoplasty after Bruns. Showing the skull lines of section.

Syphilitic Affections of the Nose.—The osseous and cartilaginous structures of the nose are preeminently disposed to syphilitic affections. A

favorite starting-point for these is the periosteum of the septum, though the alae nasi and anterior edge of the septum may become affected. In the latter case a perichondrial infiltration first occurs, followed by suppurative destruction of the cartilages. The foci of infection on the bony septum frequently lead to perforation of the latter. The spread of the destructive process leads to a sinking in of the entire nasal bony framework, producing a characteristic deformity. This sunken appearance of the nose may vary from a slight depression of the bridge to a complete flattening.

The bony framework of the nose is occasionally the seat of necrosis in laborers employed in chemical factories in which potassium salts, arsenic, and corrosive sublimate are made.

The skin of the nose is rarely the seat of syphilitic affections; if these occur at all, it is late in the destructive process, and they are the result of extension from within, particularly from the septum.

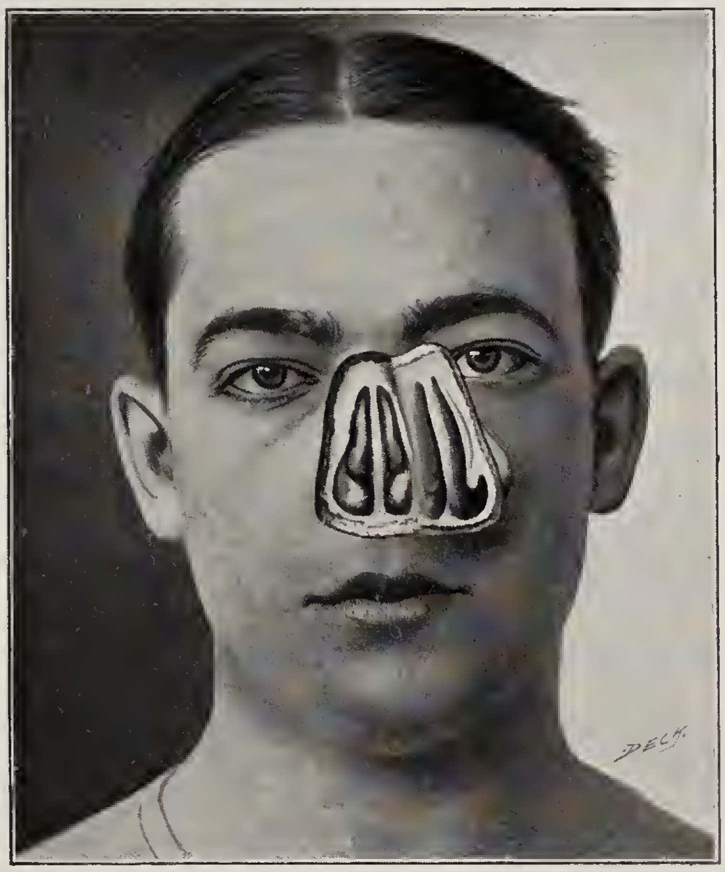


Fig. 288.—Bruns's Method of Osteoplastic Resection of the Nose.

Syphilitic disease of the nose is to be treated, at first, on an antisyphilitic basis. Subsequently when the destructive process has terminated, plastic operative procedures are indicated to overcome existing deformities (*vide infra*).

Tuberculous Affections of the Nose. — **Subperichondrial abscess of the nose** may occur in strumous children. These occur bilaterally, as a rule, the swelling closing the nostrils like a tumor of the septum. Fluctuation is easily discovered and a free incision will give exit to the pus. As a rule, perforation of the septum has taken place, but the perichondrium closes this in and the opening is not permanent, as in syphilis. The evacuated fluid is not always pus, but is sometimes light and viscid.

Tuberculous ulceration and **granulating proliferative processes** may attack the nose, the latter process occurring particularly at the septum.

RHINOPLASTY

This operation is performed for deformities that are the result of the following:

1. Destruction of a portion or all of the bony framework of the nose and adjacent osseous structures. Complete destruction of the bony framework usually results from syphilis, and rarely from tuberculous disease. Loss of portions of the nasal bony structure is due to suppurative processes following injuries. Depressed fractures, giving rise to the deformity known as "saddle nose," also require a rhinoplastic operation.

2. Partial loss of both bone and soft parts, caused by syphilis, lupus, and carcinoma. It may likewise follow injuries. The procedure, under these circumstances, is known as **partial rhinoplasty.**

3. Complete loss of the organ resulting from saber cuts, shell and gunshot

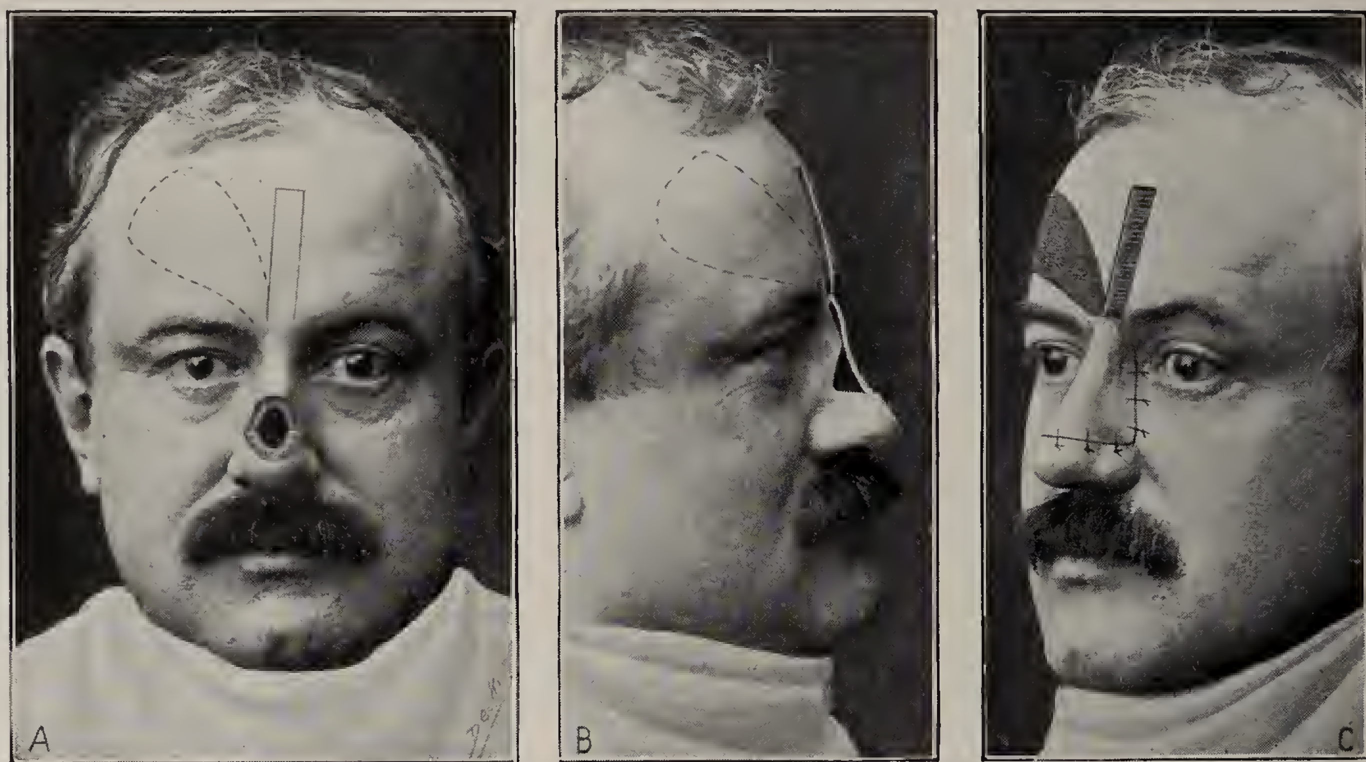


Fig. 289.—König's Osteoplastic Rhinoplasty.

A, The upturned tip of the nose restored by a transverse incision; the lines for the osteoplastic bridge and the integumentary flap appear on the forehead; B, the osteoplastic bridge in place; C, the flap with pedicle, taken from the forehead, sutured in position.

Fig. 290.—Partial Rhinoplasty.

A, Rectangular flap from healthy part of nose; B, rectangular flap from healthy part of nose covering the defect.

wounds, etc. The operation intended to correct the resulting deformity is known as **complete rhinoplasty.**

Operation for Saddle Nose.—The underlying principle of these operations is that of transplantation of a flap consisting of both bone and skin

taken from the forehead to fill the gap in the bridge of the nose that has resulted from freeing the tip and restoring it to its proper position (K ö n i g). The bony portion of the flap furnishes a rigid support to prevent the soft parts from again collapsing. In K ö n i g ' s original operation a transverse incision is employed to free the upturned tip and permit its restoration. The resulting gap, which opens into the nasal cavity, is filled with an osteoplastic flap, the base of which is at the root of the nasal bridge. This flap is about two and one-half inches long and three-eighths of an inch wide. It is formed by two vertical parallel incisions extending from the root of the nose and united at their upper extremities (Fig. 289). The incisions are carried directly to the bone. A narrow groove corresponding to the incisions in the soft parts is chiseled in the bone, extending to the diploe. The outer surface is now separated from the diploe, with a flat chisel, down to its base, broken across at this point, and, together with its skin covering, inserted so that the latter presents to the nasal cavity. The lower edge of the inverted flap is slipped under the skin edge of the lower margin of the original transverse incision and there sutured. The outer or raw presenting surface of the bony portion of the flap is covered by a pediculated flap fashioned from the skin of the forehead. This is brought down into position by reversing its surface through a half twist at the base of the pedicle, and sutured in place. The gaps in the forehead are closed at once as much as possible. The pedicles are divided when union has taken place. The protuberances left by the pedicles of the reversed flaps, together with the remaining openings in the soft parts in the same situation, are corrected at a subsequent operation. I s r a e l and H e l f e r i c h employ a curved incision with its convexity upward to free the top, make the bone flap less

Fig. 291.—Busch's Method of Rhinoplasty.
Flap used to cover the defect when the septum and the tip of the nose are absent.

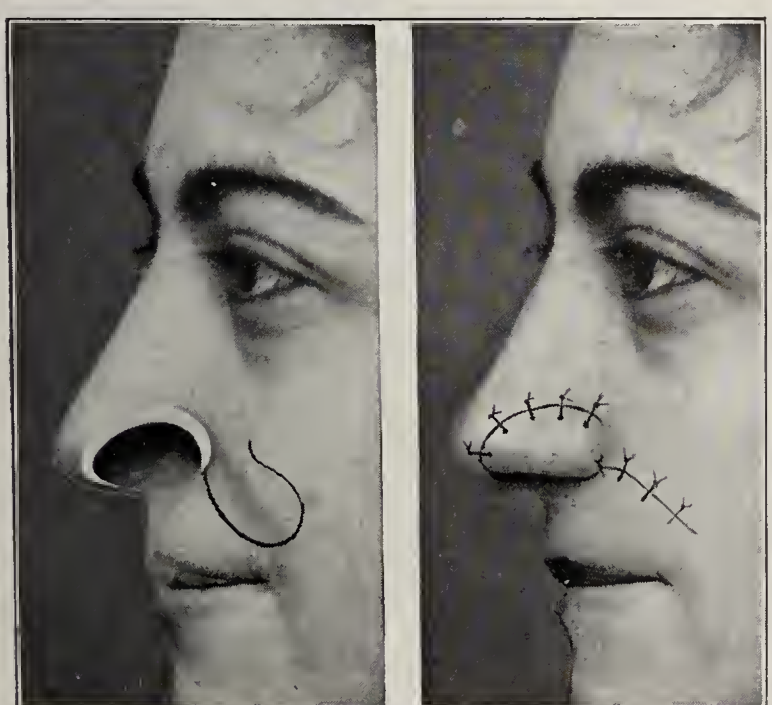


Fig. 292.—Partial Rhinoplasty.
Method of correcting a defect of the ala nasi.

than one-fourth of an inch wide, close the gap in the forehead by suturing, and leave the outer presenting surface of the inverted flap to cicatrize. When healing has taken place, the unsightly lump at the base is disposed of by making flaps from the skin beneath the turned over base of the flap and bringing these over to recover the new nasal bridge, whose cicatricial covering is dissected away for that purpose. Schimmelbusch formed a flap of skin and bone with narrow pedicle and broad base, and closed the forehead defect by sliding large curved flaps. The flap is not transplanted until its parts are well consolidated, this usually occupying a period of several weeks. Several operations are required to give a good result, which, however, is finally obtained (see Complete Rhinoplasty).

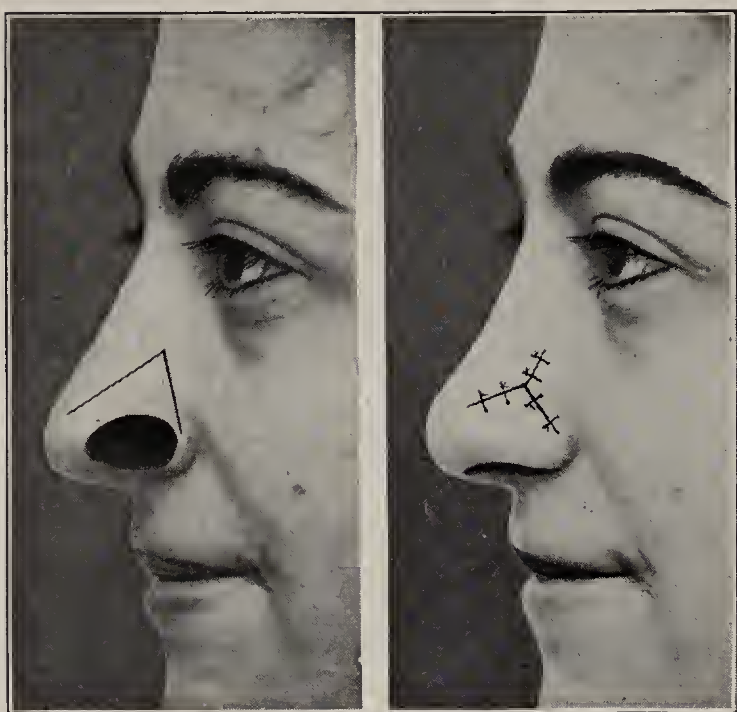


Fig. 293.—Partial Rhinoplasty. Another method of correcting a defect of the ala nasi.

Attempts to transplant detached plates of bone from the tibia, decalcified bone, etc., are not successful for the reason that the posterior surface is exposed in the nasal cavity and leads to suppuration and loss of the bony plate. In comparatively slight deformities in which restoration can be effected without opening the nasal cavity they have succeeded (Lexer). The **subcutaneous injection of paraffin** has been followed by thrombosis accidents resulting in total blindness.

Dawbarn operates for the correction of nasal bony defects as follows: Dentist's gutta-percha is softened over an alcohol lamp and molded over the nose until it fits the deformity and corrects it. It is then hardened by cooling. The patient is then anesthetized and each nostril packed with gauze well back to prevent blood from flowing into the pharynx. A knife is then inserted into the nostril and the skin and periosteum stripped from the nasal bone on the side of the deformity as widely as possible, care being taken to avoid the infraorbital vessels. In the case of a centrally placed or bilateral deformity it is necessary to enter both nostrils. The cavity thus formed is packed until bleeding is arrested, when the molded piece of gutta-percha is slipped in through the incision

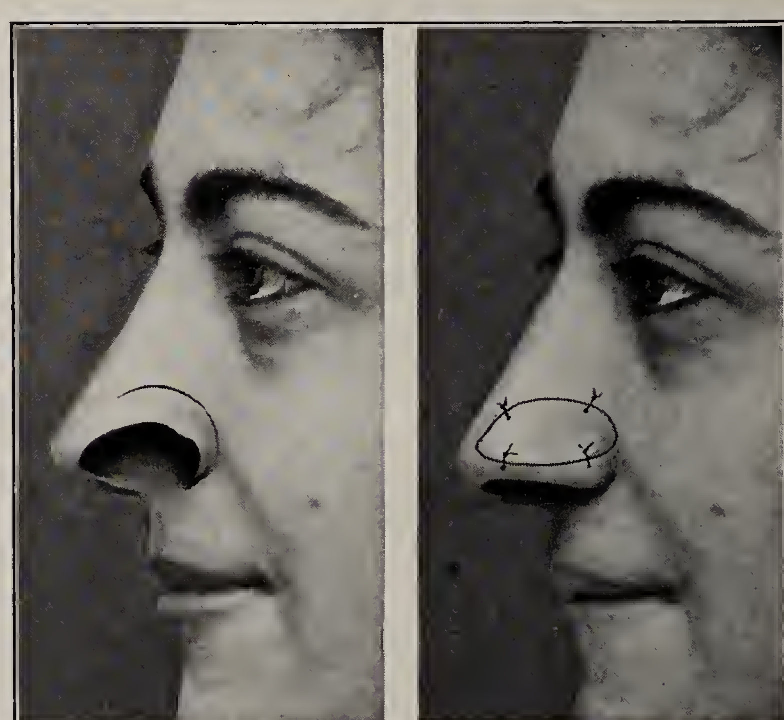


Fig. 294.—Partial Rhinoplasty. König's operation for correcting a defect of the ala nasi by transplanting a piece from the auricle.

until it occupies the site of the deformity and corrects it. The piece of gutta-percha is held in place by a small roller bandage compress on each side of the nose, and a strip of surgeon's plaster. Dawbarn claims that gutta-percha does not produce irritation, remains unchanged, and, even if suppuration takes place, this soon subsides, and the gutta-percha heals in.

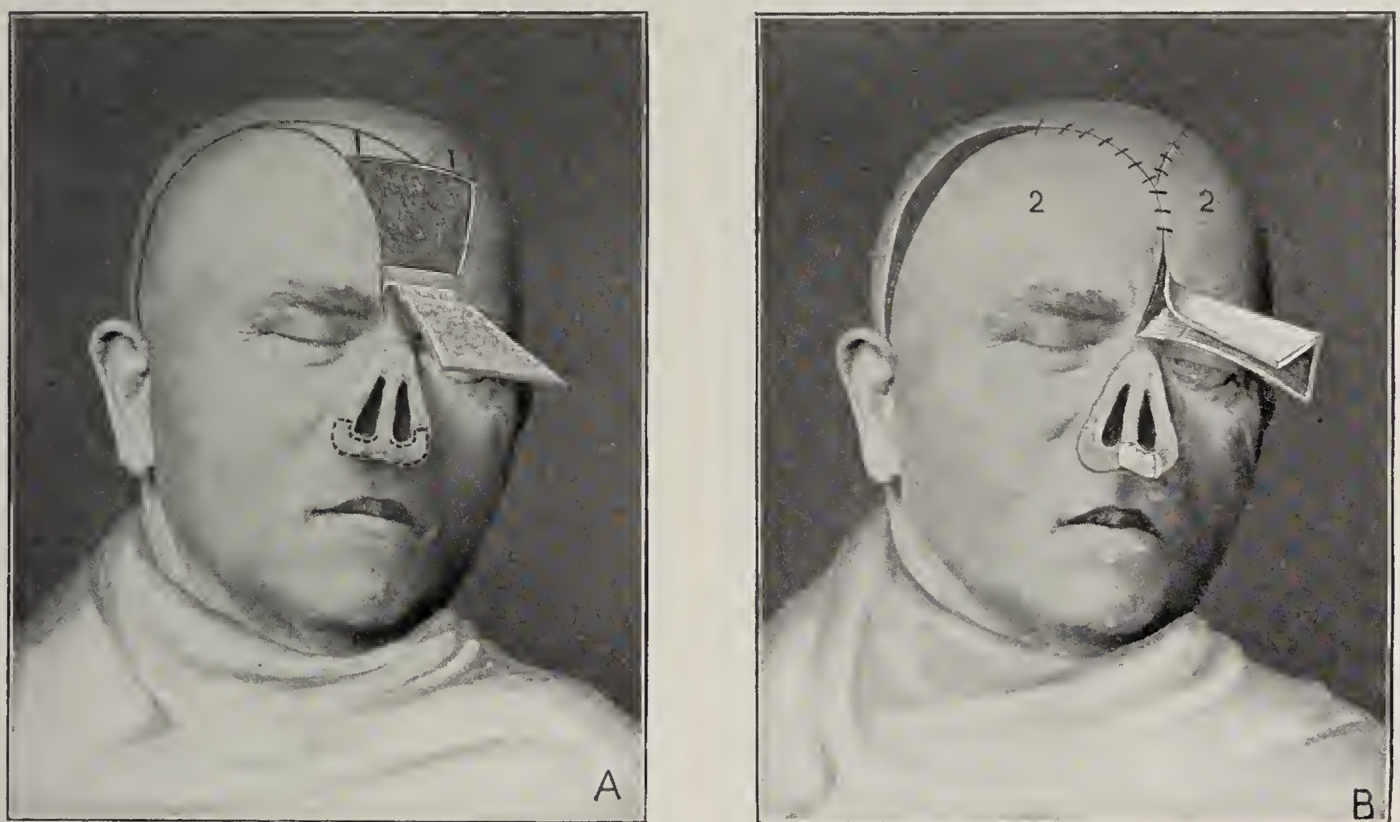
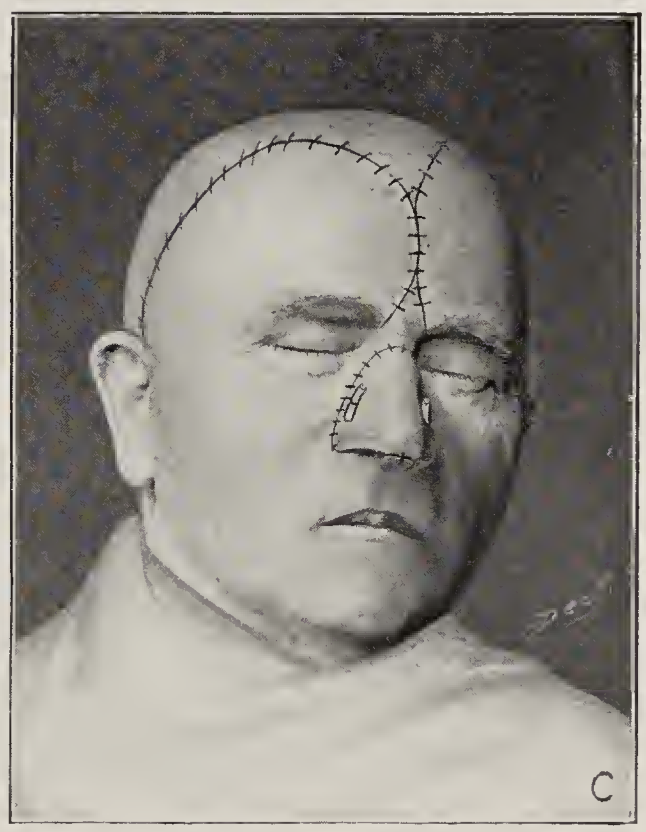


Fig. 295.—Schimmelbusch's Complete Rhinoplasty.

A. Osteoplastic flap detached from the forehead. 1, 1, Areas of skin removed to permit the sliding of the lateral flaps in position. The dotted lines about the remains of the alae nasi show the site of the incisions for the formation of the new columna. B. The osteoplastic flap covered with Thiersch skin grafts and reversed. The newly formed columna is shown in position. 2, 2, Lateral skin flaps approximated. C. Osteoplastic flap sutured in place and the pedicle severed. The stump of the pedicle is sutured to the freshened edges of the defect in the glabella region.



Partial Rhinoplasty.— Partial defects are best corrected by obliquely placed and pediculated skin flaps taken either from the forehead or from some other adjacent structure, according to the location of the defect (Fig. 290), care being exercised to have these sufficiently large to provide skin to line the edge of the newly formed ala nasi. The new defect is closed, except the opening left for the replacement of a part of the pedicle where the latter is subsequently detached.

Complete Rhinoplasty.—König's method of transplantation of an osteoplastic flap from the forehead is modified and adapted to complete rhinoplasty. The flap of the skin and bone is cut one and one-half inches wide, inverted at its base at the root of the nose, and placed temporarily over the defect. After several weeks it becomes thoroughly consolidated by the

reparative process. It is then divided longitudinally in three sections with a fine saw. The middle section serves for the new bridge of the nose. The lateral sections are separated from their connections above, but still remain attached at the lower end. These are turned downward and outward at an angle so as to form a bony tripod to support the tip of the new nose. The outer surface is freshened and covered by skin from the lateral margins of the original defect (Rotter). Or Schimmelbusch's plan of dividing the bone in the center and utilizing each half to form bony walls for the new nose in its entire length may be followed. In this method a large flap is taken from the forehead in the same manner as in the operation for saddle nose. The base of this flap before it is inverted is from three-fourths of an inch to an inch wide and its upper end from two to two and one-fourth inches wide. The defect in the forehead is closed at once by a plastic procedure (Fig. 295, A). After the separation of such necrotic portions of the bone as fail to survive (usually from four to eight weeks afterward), the granulating surface of the flap is covered by Thiersch's strips. When the healing of these is completed, the flap is sawed lengthwise to the depth of its bony portion so that it can be shaped like a double-pitched roof (Fig. 295).

The flap must now be reversed. This is done by loosening the pedicle so that a half-turn can be made in it. By this maneuver the normal skin aspect of the flap looks outward, and the Thiersch-covered side presents inward, or toward the nasal cavity. The edges of the defect, both bony and soft, are now freshened, and to these the freshened edges of the bony flap are adapted and sutured. Where sufficient tissue is present, a new columna may be formed (Fig. 295, B). In order to obviate the tendency of the new bony lateral walls to spread, and at the same time to provide for the normal depressions on each side above the nostrils, a silver wire is passed through from side to side and twisted over pieces of rubber tubing. Finally, when union of the flap is assured, the pedicle is severed. Reposition of the stump left is effected by suturing it to the freshened region of the glabella. The construction of a septum is useless as far as aiding to maintain the shape of the tip is concerned. A celluloid support or silver double tube answers the purpose much better. Eventually this need be worn only at night.

THE FRONTAL SINUSES

These are accessory to the nasal cavity, with which they communicate through the infundibulum. They are situated one on each side of the nasal spine, between the two tables of the frontal bone, and are separated from each other by a thin bony partition and from the cranial cavity by a thin bony wall which is continuous with the internal table of the rest of the skull (Fig. 296). They are absent at birth, but appear in early childhood. Up to puberty they remain of small size, when they enlarge coincidentally with recession of the brain. They are lined with mucous membrane which is continuous with that lining the nasal cavity through the infundibulum.

Injuries.—These are usually the result of direct violence, such as knife thrusts, sword cuts, projectiles, flying fragments, horse kicks, blows of the fist, falls on the face, and the like. The resulting lesions are generally those of

fracture, either a simple fissure with or without indentation, a compound comminuted fracture, or a punctured fracture. These injuries occur almost invariably in the anterior wall. Fractures of the cranial wall are quite generally fatal. Hematoma of the sinus usually coexists.

The **symptoms** are either local or cerebral, or both. Epistaxis and pain are practically the only symptoms present in simple fracture. The epistaxis may be absent in compound fracture. The lining membrane of the injured sinus is sometimes detached. The escaping secretion may simulate brain substance. Subcutaneous opening of the sinus may lead to adjacent subcutaneous emphysema (**pneumatocele**). Infection of the injured parts readily follows exposure of the cavity of the sinus, and abscess, periostitis, necrosis, fistula, and intracranial complications may result. In the absence of infection, healing is the rule. Hemorrhage from the sinus in simple fracture may sometimes be detected by rhinoscopic examination. Sinusitis with **empyema of the frontal sinus** may follow undetected fractures or simple contusions.

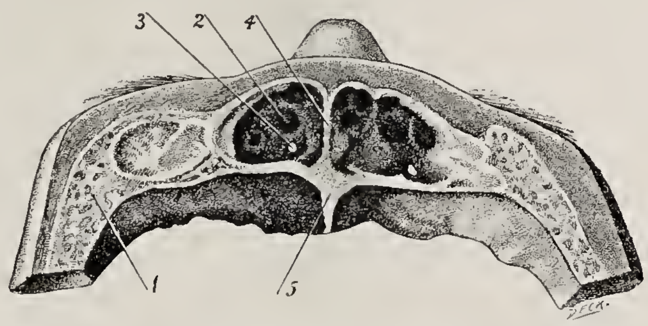


Fig. 296.—Horizontal Section through the Frontal Sinus.
1, Frontal bone; 2, frontal sinus; 3, frontal aperture; 4, frontal septum; 5, crista.

Treatment.—In all open injuries antiseptic irrigation and drainage must be practised. The possibility of intracranial complications should be borne in mind. The opening should be enlarged, the sinus thoroughly cleansed, spiculas of bone and foreign bodies removed, the cranial wall examined for possible injury, and the cavity drained. In very extensive wounds a subsequent plastic operation may be required. Pneumatocele is best treated by the application of a bandage and compression.

INFLAMMATION OF THE FRONTAL SINUS (FRONTAL SINUSITIS)

This may be either acute or chronic. The acute form generally results from a coryza, particularly in epidemic influenza.

Symptoms.—These include headache, sometimes accompanied by fever, vertigo, vomiting, etc. Ocular symptoms observed are lacrimation, photophobia, colored vision and spectra. There is a sense of pressure, with the occasional occurrence of edema of the upper eyelid and exophthalmos. The sinus outlet may become obstructed by edema, in which case the escape of the secretions by way of the nose is prevented and accumulation takes place. In the majority of cases the onset is sudden and the course of the disease brief; it usually terminates in the first week in evacuation, with subsidence of the symptoms. In a certain proportion of cases the disease becomes chronic. Periostitis of the walls of the sinus, particularly of the orbital wall, may occur. Ulceration and necrosis of the bony wall ensue with resulting infection of the orbit, or the latter may occur without previous organic change in the bony wall. Intracranial lesions may follow early in the case and occur in the same manner, in both instances the infection taking place from thrombophlebitis of the veins which traverse the walls of the sinus. Intracranial infection may be followed

by extradural and intradural abscesses, meningitis, encephalitis and cerebral abscess, thrombosis of the superior longitudinal sinus, etc.

Chronic frontal sinusitis, as a rule, is a sequel of the acute affection. It may, however, be due to an extension of an ozena or to traumatism. The frequency with which chronic sinusitis follows the acute disease is due to the fact that the anterior ethmoid cells are usually involved; with the subsidence of the acute inflammation of the sinus the **ethmoiditis** frequently remains as a source of infection. One frontal sinus may infect its fellow with or without perforation of the septum. Chronic frontal sinusitis may terminate in dilatation of the sinus or destruction of its bony walls and abscess. The symptoms may continue as in the acute stage (headache and reflex ocular disturbances) or they may subside altogether. Dilatation may develop in a short time or it may occupy years. The sinus may attain the size of a pigeon's egg or it may have a capacity of several ounces. The orbital wall usually yields first, though the entire bony capsule may suffer, molecular absorption of bone taking place in both instances. Distention of the sinus may also occur through accumulation of mucus (**mucocele**) or mucopurulent material. In about 75 per cent of the cases of mucocele the outlet of the sinus is closed.

Termination by ulceration of the lining membrane of the sinus, followed by caries or necrosis of the sinus wall and abscess, is nearly twice as common as the dilating variety. The manifestations of the disease may not occur for a long time (after the first year in one-sixth of 100 cases, Killian), the infection following a persistent anterior ethmoiditis. Sequestra form in cases of necrosis. The orbital wall is affected in about two-thirds of the cases, the cranial wall and the frontal wall being affected about equally in the remaining cases.

As in acute sinusitis, a considerable percentage of cases of infection of the orbit and encephalon occur without demonstrable lesion of the bony wall. **Cerebral abscess** is the most commonly produced lesion in these cases.

The **symptoms** of the destructive and purulent form of chronic sinusitis vary greatly. Pyorrhea nasalis may be abundant and fetid. Pain is often a prominent feature. Orbital abscess may occur. Swelling of the lids and displacements of the globe produce diplopia. Fistulous openings may follow spontaneous rupture. Optic neuritis may occur as a complication. The symptoms of intracranial infection closely resemble those which follow diseases of the middle ear.

In the **diagnosis** of suspected chronic dilating sinusitis (the "latent sinusitis" of some authors) cocainization of the middle turbinate and the use of a nasal speculum with blades adapted to the examination of the middle meatus will be of service. As a routine procedure, however, the general surgeon will resect the middle turbinate and pursue the investigation with either the probe or the cannula. The dangers arising from the use of the probe must be borne in mind; at least two fatal cases are on record due to perforation of the cranial floor by the instrument. As soon as the bent end of the instrument is an inch above the anterior process of the middle turbinate it should be within the sinus (Fig. 297). The Röntgen rays may be of service in localization of the probe. A sudden gush of pus may follow the introduction of the probe into the outlet of the sinus. This may be due to the evacuation of an empyema of the sinus, or there may be anomalies of the ethmoid cells, the pus coming from an anterior ethmoiditis. These two affections frequently coexist. If

pus does not follow the introduction of the probe, a fine cannula should be substituted and air forced in with the view of forcing out the pus. Tenderness is also an important diagnostic symptom, and when this is conjoined with orbital cellulitis, the diagnosis is placed beyond a doubt. Chronic empyema of the frontal sinus may lurk beneath the clinical picture of trigeminal neuralgia. A further diagnostic sign is a crackling sound produced on pressure, due to attenuation of the sinus walls. If exploration with the probe fails, the surgeon should make an exploratory puncture from without rather than assume the risks of a puncture from the direction of the nasal cavity. The operation may be both exploratory and curative. Simple dilatation is recognized by the local deformity and displacement of the eye, the usual absence of pain, the slow progress of the case, and the parchmentlike crackling on palpation. **Ulceration** is announced by circumscribed periostitis, abscess, perforation, fistula, or caries. Cerebral complications will give rise to characteristic symptoms. In exploratory operations it should be remembered that cerebral complications occur without perforation of the sinus wall. In doubtful cases it will therefore be necessary to expose the dura, and even to incise this if it shows evidence of infection, and to explore the cortex.

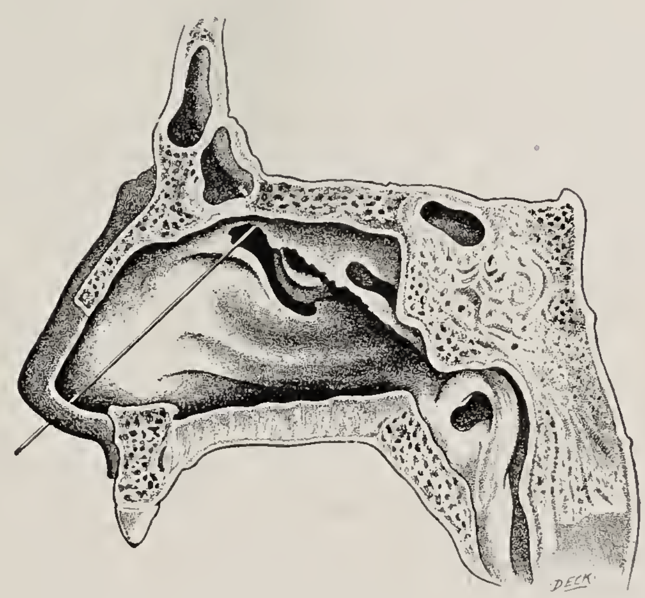


Fig. 297.—Sagittal Section through the Frontal Sinus.
Showing the probe passed into the sinus from the middle meatus (after Lichtwitz).

Treatment.—Acute frontal sinusitis requires, as a rule, only expectant treatment, such as rest in bed, diaphoresis, warm applications to the brow, inhalation of hot steam, politzerization and cocainization of the nose, and the administration of such remedies as phenacetin, salol, etc. If relief is not obtained, the middle turbinate should be resected and the sinus irrigated with warm saline solution. If the symptoms still persist and the encephalon is threatened, the sinus should be laid open from without. It may be necessary to enter the cranial cavity through the frontal wall to gain access to an abscess of the frontal lobe and effect its drainage.

In chronic frontal sinusitis it has been recommended to resect the middle turbinate as a routine procedure (Hajek). This operation of **turbinectomy** is tantamount to a radically curative operation prior to the occurrence of destructive lesions. Nothing is to be gained by it after suppurative complications have occurred. It is performed with the cold snare; one-third of the bone is removed. For the first one or two weeks after its performance an increased amount of secretion occurs, after which time mucus alone is discharged, which discharge finally ceases after a month or two. The method has only a limited range of application, and that in the hands of the expert rhinologist. It is inadequate to meet the indications in severe cases.

The operation of choice consists of an exploratory opening of the sinus, followed by simple irrigation if the bone is healthy and the mucosa free from polypoid hypertrophies. The irrigation is repeated daily (Kuhnt). In

suitable cases extirpation of the mucosa is the preferable operation (Kocher). This may be accomplished after entire removal of the anterior wall through vertical and horizontal incisions (Nebinger, Praun); or after removal of the orbital wall (Jansen); or by opening the sinus through the frontal wall, temporary resection of the corresponding nasal bone with the breaking up of the infundibular cells to insure a permanent communication and free drainage by way of the nasal fossa (Killian). A narrow bridge at the orbital margin is preserved to prevent disfigurement (Fig. 298). This form of intervention also gives access to the ethmoid labyrinth. In operations on the frontal sinus from without the posterior nares should be plugged, the incision made through the eyebrow, an exploratory puncture made through the incision, and the sinus entered by either removal of the walls or a temporary osteoplastic resection of the same. Resection of the nasal bone and division of the nasal process of the superior maxillary bone are accomplished through a prolongation of the original incision. A chisel is used in the last step mentioned, and a small portion of the frontal bone is likewise divided. Diseased ethmoid cells are removed with bone forceps and the curet and a communication established between the sinus and the nose. No irrigation is permissible until two or three weeks have elapsed (Winkler).

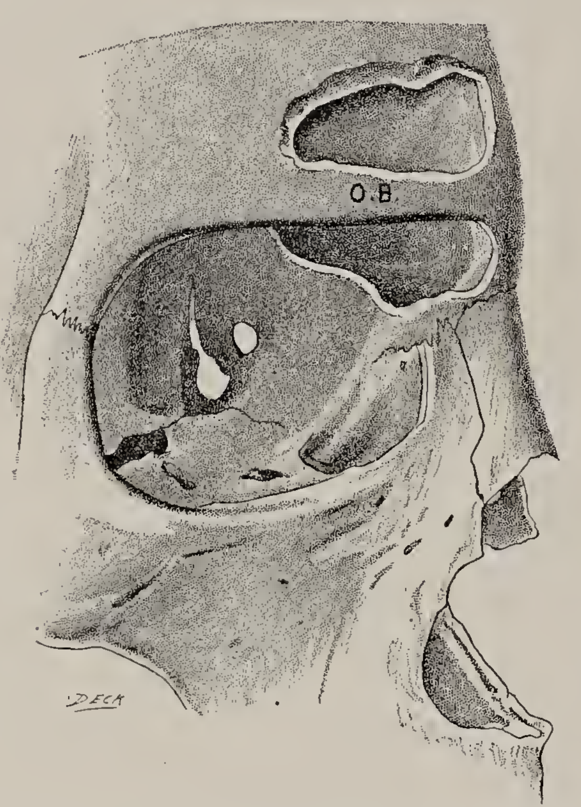


FIG. 298.—FRONTAL SINUS, THE ANTERIOR AND INFERIOR WALLS OF WHICH HAVE BEEN REMOVED, WITH THE EXCEPTION OF A NARROW BRIDGE CORRESPONDING TO THE ORBITAL MARGIN.
O. B., Orbital bridge (after Killian).

Foreign Bodies.—In the majority of cases foreign bodies in the frontal sinuses have consisted of projectiles, chiefly from old-fashioned firearms. These may heal in the sinus and remain indefinitely, but, as a rule, a fistula results. Sinusitis is invariably set up. Metallic foreign bodies are easily discoverable at the present day by the use of the Röntgen rays. There are a number of ancient cases recorded in which animate foreign bodies have gained access to the sinus, mature insects or larvae having reached there through the nasal cavities.

Tumors of the Frontal Sinuses.—Of the benign growths of the frontal sinuses **osteoma** is the most important. **Polypi** and **cysts** are regarded as essential features of chronic inflammation. Even osteomas are held by some to be of inflammatory origin. They may be attached to the bone by a broad base or pedicle or embedded in the mucous membrane, or they may lie loose in the cavity of the sinus. They are essentially confined to the period of childhood and adolescence. The nucleus and pedicle are cancellous. They may attain the size of an orange, separating the walls of the sinus and encroaching on the cranial cavity and the orbit. The functional disturbance is slight in this slow growing tumor, though exceptionally ocular disturbances, compression, etc., are produced. They may be complicated with sinusitis; they may simulate dilating sinusitis, so that an exploratory puncture may be necessary for the differentiation.

The **treatment** of osteoma is immediate extirpation under the most careful asepsis.

Of **malignant growths** originating in the frontal sinus, **sarcoma** is alone to be considered. In the recorded cases the disease advanced rapidly and invaded the contiguous cavities early. **Carcinoma** has never been known to originate in the frontal sinus and even secondary invasion is of extremely rare occurrence.

THE JAWS

Fractures of the Superior Maxillary Bone.—These arise principally through direct violence, as, for instance, a blow from a bludgeon or a stone, a kick from a vicious horse, suicidally inflicted gunshot injuries from the direction of the cavity of the mouth, etc. **Fractures of the alveolar processes** were formerly quite common, arising from the use of the old-fashioned lever or "key" used in tooth extraction. Occasionally complete separation of both upper jaws from their surroundings and attachments has been observed. Fracture of the body of the jaw, beyond a simple fissure in the wall of the antrum, is somewhat rare; the processes, as a rule, receive the force of the blow. **Transverse fracture** of both bodies of the upper jaw may be produced, nevertheless, by a blow received on the face just below the nasal bones, and a **vertical fracture,** running through the median suture of the palate and separating the two superior maxillas, may result from a blow on the chin.

These fractures are not dangerous in themselves, but **complicating conditions** that threaten life may occur. The first in importance of these is **hemorrhage from the internal maxillary artery.** This is most likely to occur in gunshot injuries. The next most important complication is **injury of the infraorbital nerve,** producing paralysis in the distribution of the nerve. **Intractable neuralgia** may likewise follow transverse and oblique fracture from final involvement of the nerve-trunk in the callus. **Suppurative inflammation of the antrum** may also occur in complicated and compound comminuted fractures.

In the **treatment** of fractures of the alveolar processes but little difficulty is experienced in replacing the fragments, since these are usually displaced in the direction of the oral cavity. They become easily displaced again, however, from the movements of the tongue, and measures must be taken to retain them in position. This is best accomplished by **wiring the teeth** of the fractured portion to adjoining teeth that are firmly fixed. On no account should the fragments be removed without a thorough trial of conservative measures, including the interdental splint (see page 522).

Fractures of the body of the bone require no treatment of themselves, yet the complications may be of sufficient gravity to demand interference. This is specially true of injury of the internal maxillary artery. Ligation of the common carotid artery is useless, owing to the free anastomosis of the internal maxillary with vessels supplied by the vertebral arteries. **Partial** or **temporary resection** of the upper jaw will give access to the bleeding point, and permit the application of the ligature, thermocautery, or tampons. Paralysis following nerve injury may disappear without treatment. In intractable neuralgia from pressure of callus the removal of the latter by chisel

and mallet is indicated (for the Treatment of Suppurative Inflammation of the Antrum, see page 529).

Luxation of the Malar Bone.—This can occur only from the application of great force. The bone may be loosened from all its connections with the upper jaw and frontal and temporal bones. Replacement and retention of the displaced bone in position are accomplished without difficulty.

Fractures of the Inferior Maxilla.—Fractures of the lower jaw, like those of the upper jaw, may involve the **alveolar processes** or the **body of the bone.** The remarks already made in connection with the fracture of the alveolar processes of the upper jaw will apply to those of the lower jaw as well.

In fracture of the body of the lower jaw the line may pass transversely so as to separate the whole of the **ascending ramus.** Fracture of the **condyle,** as well as of the **coronoid process,** may also occur. Owing to the protection afforded by the parotid gland and masseter muscle, fracture of this portion by **direct force** is rare. Fracture by **indirect force,** the latter being transferred through the mandibular arch, is likewise rare, the latter structure, being less resistant than the ramus, giving way first. Fracture of the coronoid has been observed as the result of muscular action. This fracture unites only by fibrous tissue, the strong vascular tendon of the temporal muscle, which does not produce bony callus, replacing the periosteum at this point. It is diagnosed by palpation with the finger in the mouth. Pain will be felt on pressure and displacement of the process will be observed.

Transverse or **oblique fractures** result either from direct force, as gunshot wounds or blows from a horse's shoe, or from indirect force, as compression by falls on the chin or simultaneous pressure at both angles of the jaw. They occur at the weakest portion of the bone, *i. e.*, in the region of the bicuspid or first molar tooth. Both artery and nerve are torn; hemorrhage, however, is rare, but there is usually loss of sensibility in the front teeth and the skin covering the chin. The **displacement of the fragments** is peculiar. The fracture occurs at one side of the median line, a shorter fragment corresponding to the injured side, and a longer fragment corresponding to the uninjured side. The muscles which close the jaw (temporal, masseter, pterygoid) are attached to the former, while to the latter are attached those which open the jaw (mylohyoid, geniohyoid). The shorter fragment is drawn upward, approximating the attached teeth, while the longer fragment is drawn downward, separating the teeth attached to it from those of the upper jaw. In addition, the shorter fragment is drawn toward the median line by the action of the pterygoids.

Occasionally the bone gives way in two places, the central portion being dragged downward by the mylohyoid muscles. In addition to the typic displacement, splintered fragments may be displaced in various directions.

The disturbances of function are marked. Mastication is impossible, the mouth remains partly open, the saliva dribbling. Speech is difficult, owing to inability to form the labial and sibilant sounds. Swallowing is also very much embarrassed.

The fracture is usually complicated with a wound of the mucous membrane and sometimes with a wound of the external soft parts as well. Infection from the mouth is common and **septic bronchitis** and **septic pneumonia** may occur from the passing of the inspired air over the putrid wound secretions.

The **diagnosis** does not present marked difficulty unless there is very great obliquity of the line of fracture, in which case the mobility of the fragments can be demonstrated only by grasping the bone with both hands.

Treatment of Fracture of the Lower Jaw.—The mouth is to be irrigated frequently with a boric acid solution or permanganate of potash, and in the intervals a pledget of cotton saturated with a 3 to 5 per cent solution of chlorid of zinc should be kept applied to the wound in the mucous membrane. The food must be liquid and always followed by irrigation and renewal of the chlorid of zinc pledget. Feeding is best carried on by means of a rubber tube and funnel. If there is a complicating external wound, a drainage-tube may be inserted, or if necessary an opening may be made for that purpose.

Fig. 299.—Apparatus for the Treatment of Fracture of the Lower Jaw.

If the fragments can be held in place by simple approximation of the lower to the upper teeth, measures to maintain this approximation are indicated. A Barton bandage or one of its modifications is usually employed (Fig. 195). In order to secure direct upward pressure on the mandible the following device is useful: A strip of tin 5 inches wide in front tapering to 3 inches posteriorly, with the anterior end bent upward to form a projecting shelf, is fitted to the head, to which it is secured by a circular plaster-of-Paris bandage. The anterior curved end projects from the forehead and strips of adhesive plaster pass from the shelf downward and backward beneath the jaw, exerting traction upward and forward, this overcoming the posterior displacement (Knapp). Or the head may be encased in a plaster-of-Paris cap in which two projecting iron arms are incorporated, the latter serving as points of support for the strips of adhesive plaster that pass beneath the mandible (Fig. 299).

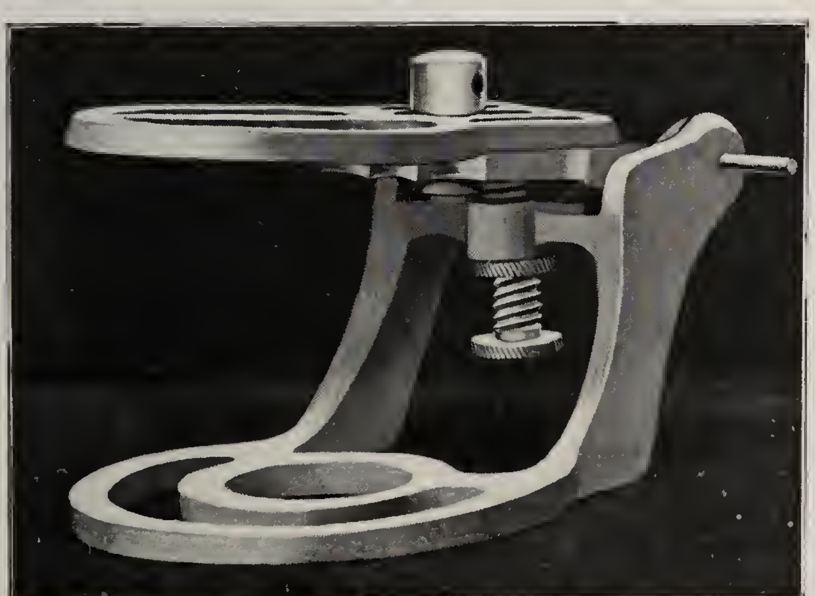


Fig. 300.—The Articulator.

The Interdental Splint.—When this method of treatment can be made available, it is by far the best method for fractures of the mandible. The

patient's mouth and teeth are carefully cleaned beforehand. It may be necessary to administer a general anesthetic. An impression is taken as for upper and lower dentures, no attempt being made to reduce the fragments. The method of procedure is as follows: The ordinary modeling cups of the dentist are filled with yellow beeswax; the latter is gradually heated over an alcohol flame and worked with the fingers until it is soft. Impressions of the upper and

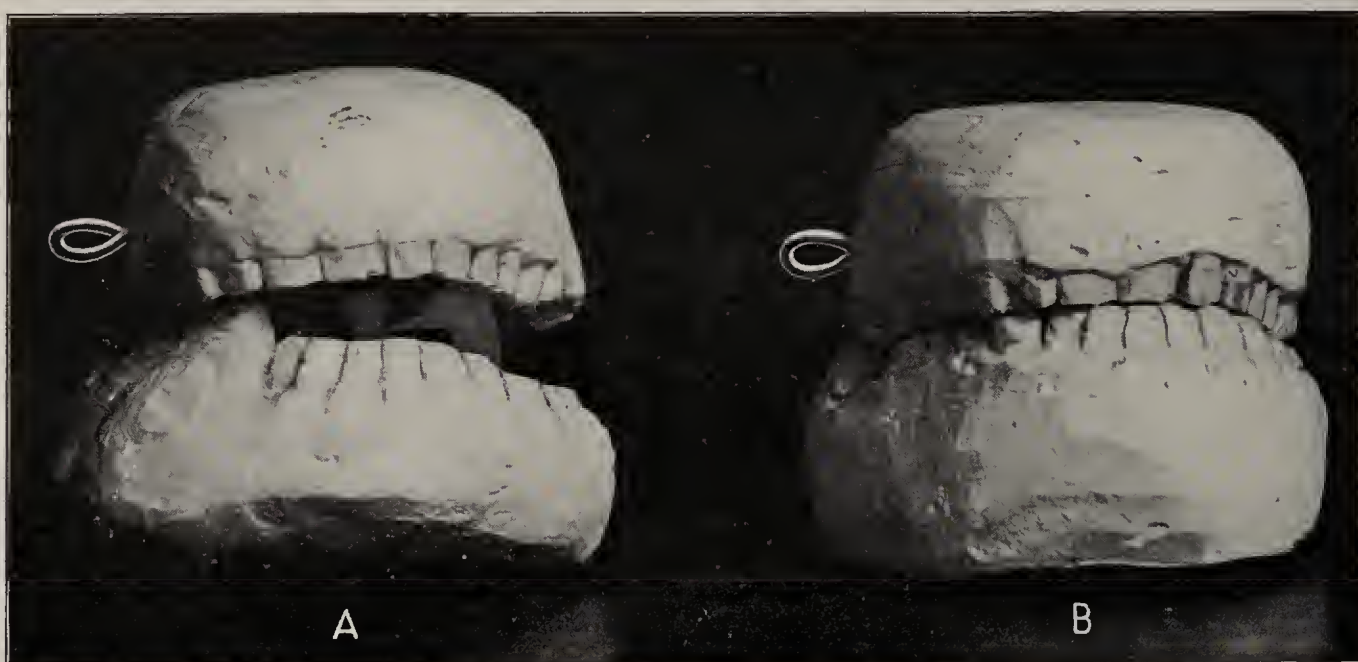


Fig. 301.—Plaster-of-Paris Models of Upper and Lower Teeth Molded in the Articulator. A, Cast of fracture of the lower jaw; B, the same after the site of the fracture has been sawed across and the normal relations of the parts restored.

the lower teeth are taken and the wax allowed to harden. A plaster-of-Paris cast of the upper jaw is then made and this is secured by means of plaster cream to the upper arm of an articulator (Fig. 300). In the same way a cast of the lower jaw is made, the site of the fracture recognized and marked, and the cast sawed in two at that point in a line corresponding as nearly as possible with the fracture.

The two pieces of the cast of the lower jaw are now brought into their proper relation so that the lower and upper teeth articulate normally; they are then fastened together by means of plaster cream on the lower arm of the articulator (Fig. 301). On this model of the reduced fracture an interdental splint of vulcanite (Fig. 302) is made by a mechanical dentist. The splint is trimmed so as not to impinge on the gums. In placing the splint in position it is first adjusted to the upper teeth; the teeth of the lower jaw are now forced into the recesses made for them on the corrected model, the displacement thus being rectified. Suitable bandages (Barton's or a modification thereof) are applied so as to hold the lower jaw firmly in place against the splint. The latter is worn for from thirty to fifty days.

Fig. 302.—Interdental Splint of Vulcanite.

The interdental splint is suitable for the treatment of fractures through the dental arch. Various slight modifications of its form may be rendered necessary

for feeding purposes so as to take advantage of any gaps in the teeth that may exist.

In fractures in the region of the molar teeth special care must be exercised not to separate the jaws any wider than is absolutely necessary in the application of the splint, lest failure of the front teeth to articulate when the healing is completed result. Here the portion of the splint interposed between the teeth should be as thin as is consistent with strength, for it is evident that the greater the separation of the jaws, the greater will be the stress on the posterior fragment. The thin gold splint of Ottolengui (Fig. 303) answers the purpose best under these circumstances.

If the fracture is in front of the bicuspid teeth, a short splint or a simple capping of the lower teeth in cases where there is little deformity will fulfil all requirements.

In cases of double fracture an interdental splint is indispensable; if one break is at or near the angle, the splint should be as thin as possible so as to avoid increasing the deformity at this point.

Roberts's Method.—A dental splint is made, as in the method last described. This is held in position by one or two loops of silver wire, the ends of which are passed through the soft parts close to the anterior and posterior surfaces of the body of the jaw, by means of a needle, and secured externally by being twisted over a roll of gauze covered by rubber tissue, or a piece of heavy rubber tubing.

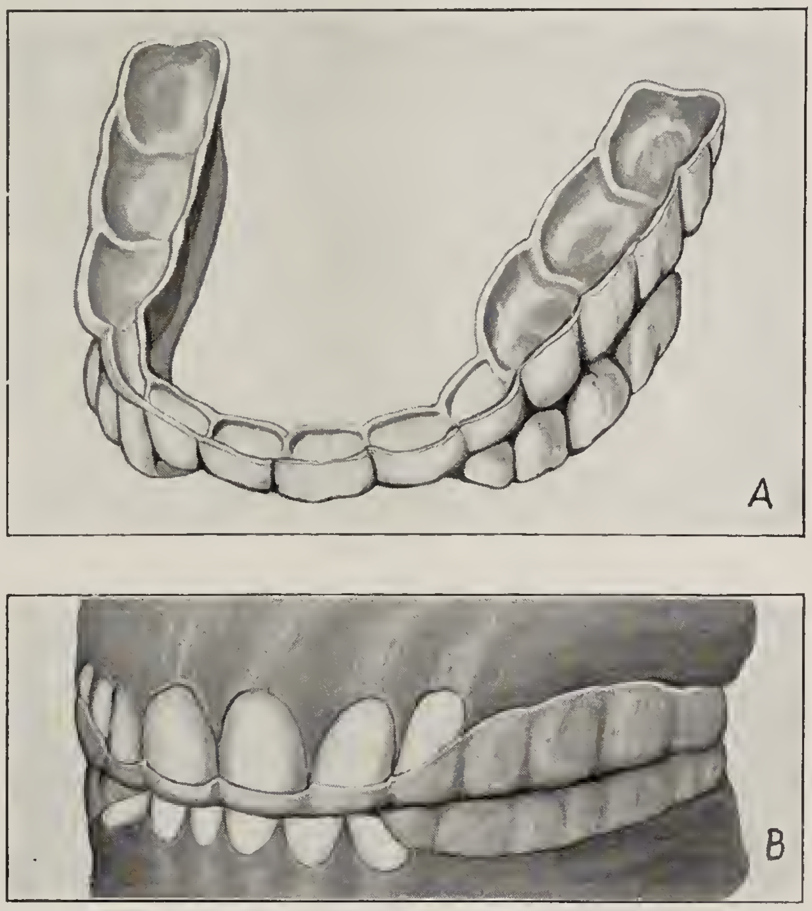


Fig. 303.—Gold Interdental Splint (after Ottolengui).

For use in cases of fracture posterior to the last molar. A, The splint; B, the splint shown in place on the plaster model.

Necrosis of splintered fragments may require subsequent removal. The union previously obtained is not generally disturbed by such removal.

Matas's Adjustable Metallic Interdental Splint.—This apparatus is designed with the object of immobilizing the broken fragments of the jaw without restricting its movements as a whole, so that it permits the mouth to be opened and closed at will. It is specially adapted for compound fractures of the symphysis and body of the jaw. It consists of the following parts:

1. A detachable dental plate or mouth-piece, made of block tin (Fig. 304). This is hollowed to fit loosely over the crowns of the teeth. Its edges form two flanges which project downward, the one on the outer or buccal side extending to the neck of the teeth, while the one on the inner or lingual side is longer and almost touches the gums when applied. Two partial sections of the splint are made approximately on a level with the bicuspids; they include the width of the splint to its outer rim. These sections are for the pur-

pose of increasing the inflexibility of the splint, thus facilitating its adaptation to different forms of the lower dental arch. The hollow groove or gutter in the splint can be filled with dental wax; this serves to hold loose teeth in place, to reduce the mobility of the splint to a minimum, and to overcome the difficulty of obtaining a uniform compression caused by the vertical irregularities of the teeth. The splint is made in three sizes.

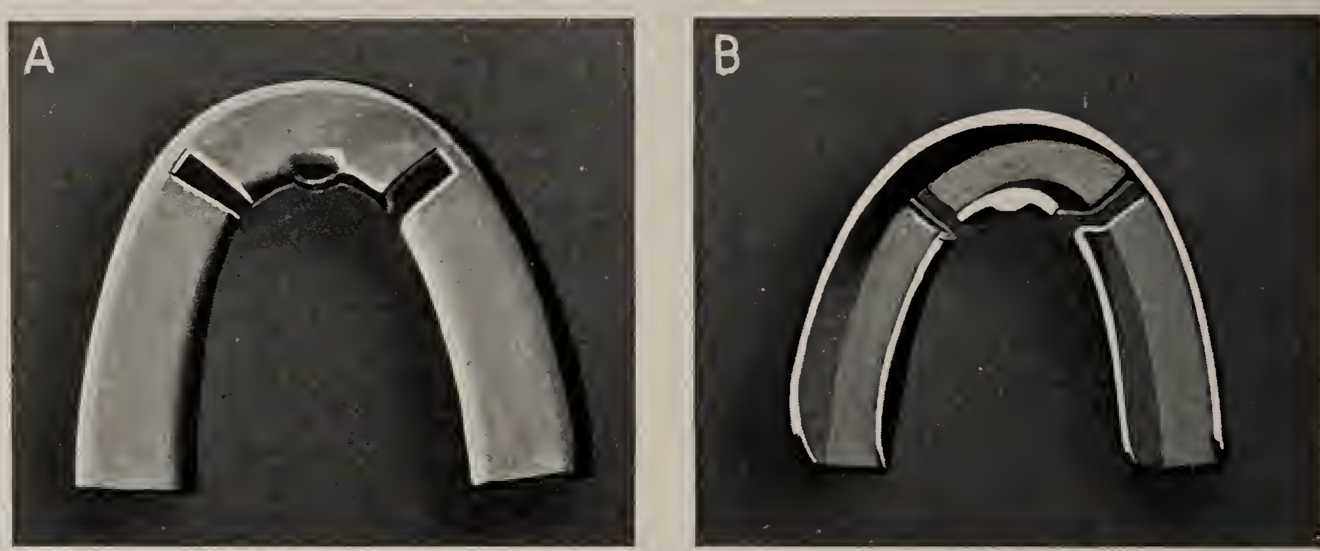


Fig. 304.—Matas's Adjustable Splint for Fracture of the Lower Jaw.
A, Upper view; B, lower view, showing partial sections cut in the soft block-tin mouth-piece to facilitate adaptation to different forms of the lower dental arch (after Matas).

2. An adjustable chin-piece made of perforated aluminum, shaped to fit the contour of the lower jaw, and secured to the lower arm of the clamp by a thumb-screw (Fig. 305). In order to prevent injurious pressure on the skin, the chin-piece is padded with cotton wadding or felt covered with gauze smeared with oxid of zinc ointment.

3. A clamp which holds the mouth-piece and chin-piece together. This consists of an upper and lower arm connected together by a joint, and capable of adjustment by means of a screw attached by a swivel joint to the upper arm (Fig. 305). The pressure required to hold the interdental splint and chin-piece firmly in position when applied is obtained by this screw.

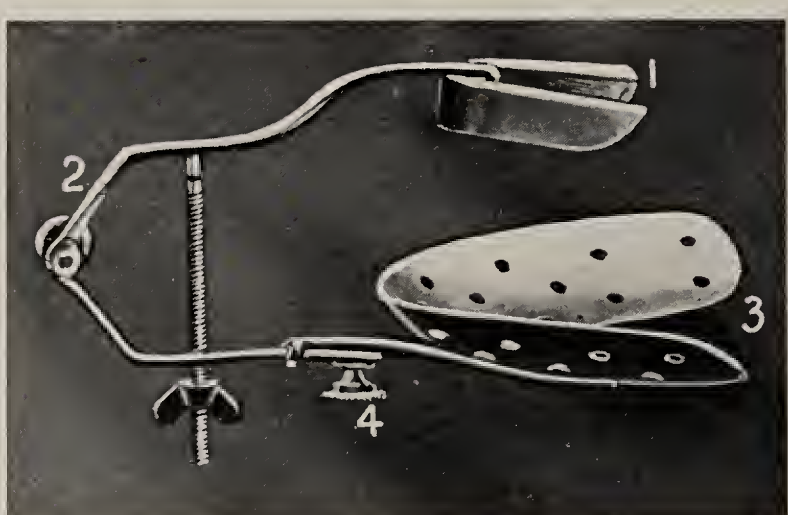


Fig. 305.—Matas's Adjustable Splint for Fracture of the Lower Jaw.
1, Block-tin interdental splint; 2, clamp adjusted and tightened with a screw; 3, chin plate of aluminum, which can be moved backward and forward and secured by the screw 4 (after Matas).

Where extensive comminution is present, the block-tin interdental splint may be used without the clamp and chin-piece, the latter being substituted by a molded chin splint made of coarse flannel thoroughly soaked in plaster cream, and held in place by a plaster-of-Paris or a starch bandage.

After reducing the fracture and restoring the contour of the dental arch, preferably under an anesthetic, the splint is fitted to the arch of the teeth by molding with the fingers. If the dental wax is used, this is softened in hot

water and spread over the gutter surface of the splint; the splint is then applied and held in place until the dental wax cools. The clamp is attached

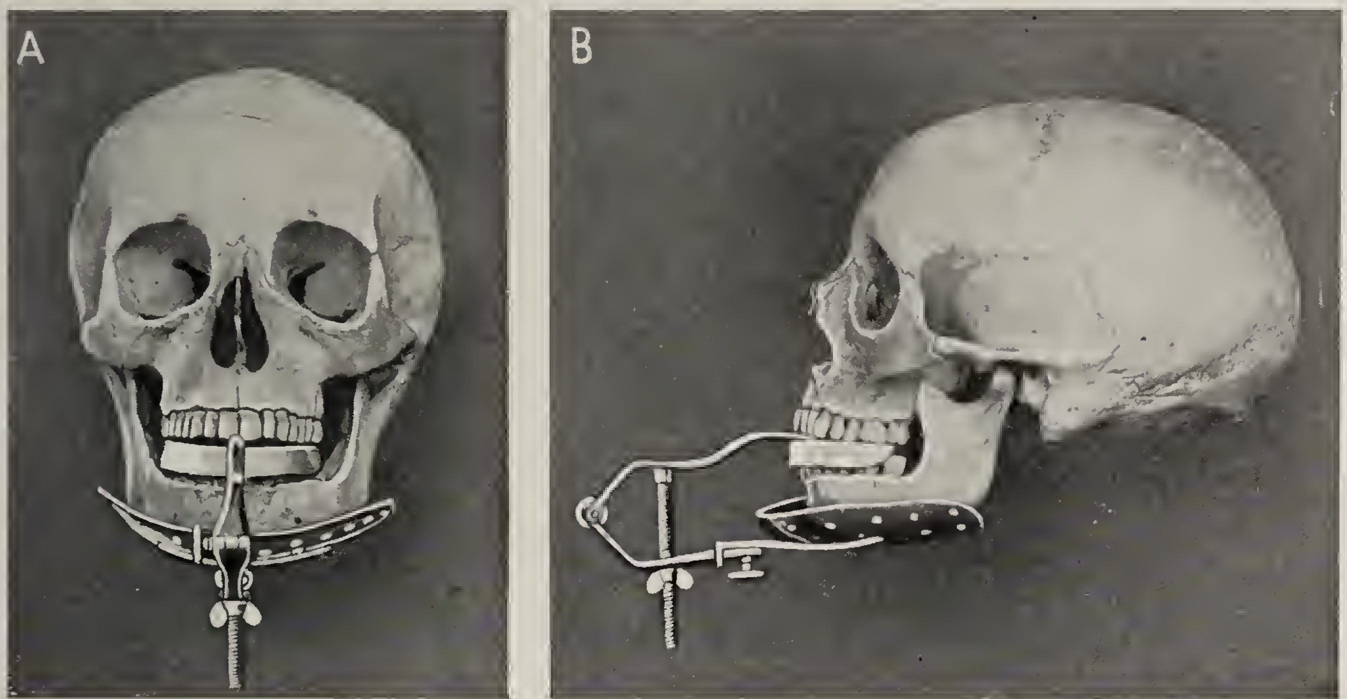


Fig. 306.—Matas's Adjustable Splint for Fracture of the Lower Jaw. Shown on the adult skull. A, Front view; B, lateral view (after Matas).

to the splint after the latter has been adjusted to the jaw, by means of a hook at the tip of the clamp, which fits in a groove or slot in the center of the inner surface of the splint.

If great swelling takes place, or necrosis of the skin of the chin is threatened, the pressure of the screw must be relaxed from time to time. Frequent irrigation of the mouth must be practised.

Dislocations of the Lower Jaw.—A meniscus separates the two articular surfaces of the temporomaxillary articulation, constituting what is called a "double joint." The opening and closing of the mouth, the forward and backward movements of the jaw, as well as those made in grinding and marked by a simultaneous backward movement of one condyle and a forward movement of the other, are performed through the medium of this interarticular cartilaginous plate.

Fig. 307.—Matas's Adjustable Splint for Fracture of the Lower Jaw.

The splint is adjusted in position. The apparatus is held in place by a Gibson or Barton bandage (after Matas).

In spite of its apparent great freedom of motion dislocation occurs in but one direction, namely, forward (Fig. 308), and then usually by forcible efforts at opening the mouth (gaping). During this act the condyle,

with the meniscus, is forced on the articular eminence, and, in case the posterior wall of the capsule gives way, the condyle with the meniscus is carried in front of the articular eminence, from which position the masseter is unable to extricate it by attempts at closing the mouth. Lax conditions of the capsule, either congenital or acquired through nutritive disturbances, predispose to the accident. In such cases clicking sensations referred to the joint and due to abnormal movements of the meniscus (a form of subluxation) occur.

External force, such as a blow on the teeth when the mouth is wide open, may give rise to the dislocation.

Habitual Dislocation.—After a dislocation has once taken place, the condition may occur from slight causes. This is due to the formation of a broad cicatrix during the process of healing of the torn capsule.

Fig. 308.—Dislocation of the Mandible.
Method of reduction by a pry made of a piece of splint material covered with a bandage.

Dislocation of the jaw is very rare in children. This is due to the fact that the articular eminence is absent, and hence there is no obstruction to the sliding movements of the meniscus when this is thrown forward as the mouth is widely opened.

Symptoms.—The open mouth, dribbling saliva, and projecting front teeth form a characteristic clinical picture. With the index-finger introduced into the external meatus auditorius the normal depression felt when the mouth is opened is found to be greatly exaggerated. The prominence of the coronoid process is carried anteriorly and is felt below the middle of the zygomatic arch.

Treatment.—Reduction is accomplished by pushing both coronoid processes below the articular eminence. The thumbs of both hands are placed

with the palmar surfaces downward on the lower molars of each side, the points of the fingers resting on the lower edge of the body of the jaw, and the two little fingers meeting beneath the point of the chin. The back molars are pressed downward, and at the same time the point of the chin is elevated by the two little fingers. Or, a pry may be improvised from a common desk ruler, or piece of splint material covered with bandage muslin (Fig. 308). In some cases it may be necessary to make pressure on the coronoid process from within the mouth. In old cases Stromeyer's forceps, constructed so as to grasp the lower molars and the chin, afford a longer leverage for the manipulation. In cases otherwise irreducible, open incision and removal of the obstruction to reduction, or resection, may be performed. **Unilateral dislocations of the lower jaw** are very rare. They are reduced without difficulty by the manipulations already described.

In an intractable case of habitual dislocation of the lower jaw I succeeded in correcting the tendency to recurrence by the following operation: The parts were exposed through an incision, the temporomandibular articulation opened at the site of the external lateral ligament, a portion of the latter removed so as to shorten the ligament, and the eminentia articularis chiseled away. The external lateral ligament was then sutured and the external wound closed.

Inflammation of the Gums.—**Subperiosteal or alveolar abscess,** the result of **caries of the teeth,** may advance from the alveolus and find its way beneath the gum. These suppurative processes should be opened early and treated by an antiseptic mouth-wash. **Metastatic (pyemic) abscesses** may result from their presence. Their recurrence, or the persistence of a fistulous opening, usually requires the removal of the offending tooth. If this is neglected, the pus may finally burrow beneath the periosteum and other fistulous openings form; or, the pus may continue to burrow, reaching the region of the angle of the jaw, or that of the symphysis menti in the inferior maxilla, or the infraorbital region in the superior maxilla, pointing externally.

This development of **suppurative periostitis of the jaw** is accompanied by swelling of the soft parts, pain, and occasionally high fever. **Multiple pyemia** may develop as a consequence, or life may be threatened, in the case of the upper jaw, by an extension of inflammation along the nerves to the base of the skull. Usually, however, the affection pursues a favorable course. Free incision and antiseptic treatment promptly relieve the symptoms, but a fistula leading to the carious root of a tooth or to a necrosis of the alveolar process is left. The tooth must be extracted and all diseased portions scraped away. In more extensive necrosis of the jaw **sequestrotomy** is necessary, the fistulous opening being utilized for a portion of the incision for this purpose, if it is found impracticable to remove the sequestrum from the inside of the mouth (**intrabuccal sequestrotomy**), a procedure always desirable, on account of the cosmetic effect. This will be facilitated by waiting until the sequestra have become loosened, free drainage and antiseptic treatment being employed in the meanwhile.

The cutting of a wisdom tooth in adults may be so painful as to require an incision at the hands of the surgeon.

Gingivitis.—This is an affection in which the edge of the gum surrounding the tooth is inflamed and sometimes ulcerated. It originates from septic inflammation arising from decomposition of food. It appears as an epidemic

affection, occasionally several children in the same family being attacked. The affection readily yields with the use of an antiseptic mouth-wash, such as permanganate of potash or chlorate of potash. Cleansing the ulcerated edges with absorbent cotton dipped in a 2.5 per cent solution of carbolic acid is useful, in conjunction with the above. The affection should not be confounded with **scurvy.**

Lead Poisoning.—This gives rise to a peculiar grayish-blue discoloration of the gums. Ulcerative destruction of the gums is observed as a result of **mercurial stomatitis. Deposits of tartar** may also give rise to inflammation and ulceration of the gums.

Necrosis of the Maxillary Bones.—In addition to necrosis resulting from suppurative periodontitis already mentioned, which gives rise more commonly to small sequestra, the two following diseases, though rare, constitute much more serious affections.

Phosphorus Necrosis.—Employees of match factories, prior to the enforcement of certain hygienic rules, suffered from this disease. The etiology of the affection is obscure. It appears to be due to the exposure of carious teeth to the fumes of the phosphorus, though a bacteriologic origin has been suggested, the phosphorus in some unknown manner favoring the development of the fungi. The sequestra separate very slowly, and new bone forming over the diseased osseous structure, if exposed to the phosphorus fumes, in its turn becomes diseased. The processes are exceedingly putrid; **septic bronchitis** and **pneumonia** may supervene, or even general infection ensue.

Early antiseptic treatment is imperative. Necrosed portions of bone are to be removed. This more frequently involves a resection of the entire bone than a sequestrotomy. If the periosteum is preserved or an involucrum of healthy bone has formed, reproduction of the entire bone may take place.

Acute Infectious Osteomyelitis.—This occurs exclusively in the lower jaw, as it alone possesses a medullary cavity. It is an exceedingly dangerous affection, though of slow development. It may follow the exanthemata of children. The treatment consists in early and free incisions. Edema of the glottis and subsequent suffocation may occur after inflammation of the soft parts. **Intrabuccal sequestrotomy** should be performed, whenever practicable, to avoid extensive cicatrices on the face. If external incisions cannot be avoided these should be placed along the line of the jaw.

Necrotic Caries.—This attacks by preference the superior maxillary bone at the infraorbital ridge, and the malar bone. It is usually of tuberculous origin. The treatment consists in the vigorous application of the sharp spoon or the removal of small sequestra. An ugly depressed scar results; this may lead eventually to **ectropion,** and require the operation of **blepharoplasty** (see page 495).

Inflammation of the Antrum of Highmore.—Inflammation of the antrum, or maxillary sinus, occurs either from extension of catarrhal rhinitis through the lower nasal duct, from frontal sinusitis, ethmoiditis, various nasal obstructions, such as nasal polypi damming up the secretions in the middle meatus (Cryer) and enlarged middle turbinates, from extension of inflammation from periodontitis, particularly of the posterior molars, or from suppurative periostitis of the walls of the superior maxillary bone. The dis-

ease occurs only in adult life; the antrum is not developed in childhood.* The right side is affected in 75 per cent of the cases. Five cases out of 140 were bilateral (Cline).

Hydrops of the Antrum.—This arises from a **serous inflammation** of the lining of the antrum; this latter is the most common of the affections of this cavity. The opening communicating between the antrum and the nasal duct is small and easily closed by a slight inflammatory swelling, an accumulation of the products of inflammation resulting. The portion of the maxillary wall corresponding to the canine fossa becomes bulging, and even the entire half of the face may become unduly prominent. The condition may simulate malignant disease of the superior maxillary bone. In the latter, however, the tumor develops through the palate and nasal fossa, while in the former these structures are the least affected. In malignant disease the bony wall of the canine fossa is converted into a soft mass; in hydrops this usually becomes thinned so that palpation discloses the so-called parchment crepitation. If the bone preserves the normal consistency or becomes thickened by inflammatory irritation, this crepitation may be absent.

Other causes of hydrops of the antrum are said to be **abnormal growths of a wisdom tooth** (McCoy), **polypi** and **mucous cysts,** or **cystic degeneration of the mucous membrane** (Adams, Wernber).

Suppurative inflammation may develop from a simple hydrops or from suppurative inflammation of the adjacent molars. The occurrence of suppuration is marked by pain, fever, and edematous swelling of the cheek. The disease may terminate in perforation of the bony wall of the antrum, particularly at the inner portion of the infraorbital ridge, or the periosteum of the antrum may become attacked and necrosis result.

Treatment.—Acute cases of simple serous inflammation of the antrum usually subside without operation. Operative measures are demanded, however, both in chronic serous inflammation and in suppurative inflammation. If crepitation is present, an incision may be made at the thinnest part as an emergency measure. This can almost always be accomplished from within the mouth by passing the blade of a stout knife from the direction of the gums. If a carious tooth or the roots of a tooth are present, the extraction of these will usually open the way into the antrum. If not, a hole may be drilled into the cavity from the bottom of the tooth socket and the contents evacuated.

For the radical cure of suppurative inflammation of the antrum the following operation best fulfils the indications: The nasal passages are first thoroughly cleared of polypi, turbinate hypertrophies, and other causes of obstruction. A curved incision is made at the site of the root of the corresponding bicuspid tooth in such a manner as to reflect a flap from the gingivolabial fold of mucous membrane and expose the anterior wall of the antrum at this point. The latter is then perforated and access gained to its cavity. The opening is enlarged sufficiently to permit the introduction of a curet, and the entire cavity is thoroughly curetted. The nasal cavity is then entered on a level with the lowest point of the antral cavity by per-

* Rudaux ("Ann. d. mal. de l'oreille et du larynx," Sept., 1895) reports the case of an infant three weeks old, in whom empyema of the antrum was due to the presence of a prematurely developed tooth in the floor of that cavity. The presence of the latter at this early age, it is presumed, was likewise the result of a premature development.

forating the inner bony wall from the direction of the latter. This opening should be enlarged by the removal of sufficient bone to allow for subsequent contraction.

The mucous membrane flap at the site of the original opening is sutured in place. The subsequent treatment consists in frequent antiseptic irrigation from the direction of the nasal cavity. This is to be continued until the purulent discharge into the nasal cavity ceases. The free communication between the latter and the cavity of the antrum insures against a relapse.

Malignant growths of the antrum of Highmore occur, both as sarcomas and as carcinomas. Neuralgic pains referred to the teeth at the commencement lead to the extraction of the latter. Symptoms of inflammation of the antrum appear, with mucopurulent discharge from the nose. Swelling of the soft parts of the superior maxillary region occurs, with reddening and soft edema. Implication of the skin of the cheek finally takes place. The globe is displaced by the crowding upward of the orbital plate (see Fig. 309), with resulting **exophthalmos.** Occlusion of the tear duct leads to overflow of tears on the cheek (**epiphora**). The anterior wall becomes thinned from expansion of the walls of the cavity. The nasal fossa is encroached upon and respiration thereby obstructed. In some cases the alveolar border is depressed. Ulceration of the part projecting into the nasal fossa gives rise to frequently recurring hemorrhage. Finally, the growth makes its way through the posterior wall and invades the zygomatic and sphenomaxillary fossa, thence passing into the temporal fossa; or it may pass through the sphenomaxillary fissure to the orbit, or through the sphenoidal fissure or the foramen rotundum into the middle fossa of the cranium.

Fig. 309.—Sarcoma of the Antrum.

The mucoperiosteum of the antrum is a common situation for **periosteal sarcomas.** The disease is most frequently observed in youth and before middle life. Sarcoma as it springs from a tooth follicle is confined exclusively to children. The germ of the first permanent molar is a favorite situation for these growths.

Primary epithelioma as it affects the antrum is a rare and insidious disease occurring in patients past middle life. It commences with pain in the upper jaw, followed by a fullness of the parts, edema of the lids, and brawniness of the skin of the cheek; the latter finally breaks down into an ulcer. The growth extends into the orbit and along the pterygoid muscles. The lymphatic glands of the neck are involved late in the disease. Metastases to internal organs are rare.

The **treatment** demands complete resection of the upper jaw (see page 537).

Contracture of the Lower Jaw; Lockjaw.—This is frequently due to inflammatory conditions in the neighborhood of the mandibular arch and the lower portion of the ascending ramus. Lockjaw of arthritic origin is extremely rare.

The inflammatory conditions giving rise to acute lockjaw are (1) periostitis; (2) paradenitis following inflammation of the lymphatic glands in the submental and submaxillary region, and of the submaxillary salivary gland; (3) parotitis; (4) aggravated forms of acute tonsillitis with involvement of the peritonsillar connective tissue; (5) osteitis of the lower jaw from any cause; the immobility of the jaw ceases, however, with the subsidence of the inflammation in the majority of cases.

The **cicatricial form of lockjaw** constitutes a more frequently observed and most intractable form of contracture. This results from the presence of solid cordlike bands of cicatricial tissue following destructive ulcerative changes (**noma**) which have their origin, as a rule, on the buccal mucous membrane. The acute inflammatory suppurative conditions above alluded to may, though rarely, result in the formation of cicatricial tissue and give rise to cicatricial lockjaw.

Bony fusion (synostosis) of the temporomandibular articulation has been observed, though, as before stated, the arthritic form of contracture in this joint is rare. This articulation, however, is not exempt from the diseases which attack other articulations. **Disease of the coronoid process** may also give rise to lockjaw.

Treatment of Lockjaw.—This will vary with the origin of the condition. The **preventive treatment** consists in placing a cork between the teeth, first locating it between the incisors, then between the canine teeth, and finally between the molars. In the beginning of contracture of inflammatory origin, including that due to the development of cicatricial tissue, this method may be tried.

The **operative treatment** consists first in attempting to separate the jaw by means of wooden wedges, the patient being placed under an anesthetic. This failing, **intrabuccal** or **subcutaneous division** of cicatricial bands may be tried. Usually, however, it will be better to **dissect away the cicatricial tissue** and supply its place by an attached skin flap from the cheek, passed through a slit in the cheek. The base of the flap is subsequently separated and the slit closed.

The **formation of an artificial joint** in front of the point of cicatricial or bony contracture (Esmarch, Wilms) is a procedure which may be resorted to with advantage. About half an inch of the bone is removed and mobility established through subsequent passive movements. This is preferable to **Rizzoli's operation** of simply sawing through the mandibular arch, for the reason that the latter operation is frequently followed by reunion of the fragments.

In **convulsive** or **spasmodic lockjaw** operative treatment is of no avail. The older operations of myotomy and tenotomy for this condition should be abandoned.

Resection of the condyle is indicated in contractures originating in disease of the temporomaxillary articulation. Difficulty is usually experienced in removing the head of the bone from the glenoid fossa. In cases of disease of the coronoid process the latter may become welded to the upper jaw by bony proliferation; this may be divided by the chisel and mallet or narrow saw.

Benign Tumors.—The maxillary bones, from their peculiar formation, the processes of dentition, the presence of the antrum, and irritations arising in the oral cavity, are specially disposed to tumor formation.

Subperiosteal abscesses, when not opened, give rise to a separation of the periosteum, the latter forming a new bony layer. The symptoms of crepitation may be present, or the tumor may assume a solid consistency. This constitutes the so-called **subperiosteal cyst of the alveolar process.** The pus which originally filled the cyst changes to a clear mucous fluid, which, from the presence of crystals of cholesterin, sometimes looks like butter. These cysts sometimes attain the size of a hazelnut and empty their contents into the antrum. Extraction of the roots of carious teeth is usually sufficient for a cure. If not, the bony wall of the cyst must be incised.

Fibromas.—These are of rare occurrence. They develop at or about the twentieth year of life in strong and healthy individuals and sometimes attain the size of a walnut. Their favorite location is the alveolar processes of the canine teeth. They are generally of osteal origin, though they may spring from the periosteum. They are usually of almost bony hardness. They are best treated by resection of the alveolar process from which they spring. Recurrence after complete removal is not observed.

Odontomas.—These are peculiar growths which appear in young individuals. They consist of cystic formations surrounded by bony walls, arising from either tooth germs or the teeth. The cysts contain either a number of teeth, or one giant tooth, the result of the fusion of the germs of several teeth, or fibromatous or chondromatous masses may inclose displaced tooth germs. Their usual location is the neighborhood of the last molar. The treatment is by extirpation.

Osteomas of the Maxillary Bones.—These sometimes attain a very large size. They are exceedingly benign, becoming troublesome only by their persistent but slow growth, and the great deformity which they produce. The globe may be displaced forward, and cerebral disturbances may follow their invasion of the base of the skull. Visual disturbances are not observed as a result of stretching of the optic nerve, from the fact that this takes place very slowly.

Adenomas and **chondromas** of the maxillary bones occupy a midway ground between benign and malignant growths. They are much rarer in their occurrence than sarcomas and carcinomas.

Malignant Tumors.—These consist of sarcomas and carcinomas. Of these, the former are the more frequently observed.

The **superior maxilla** is not infrequently the seat of **periosteal sarcoma.** It often arises from the mucoperiosteal structure of the gums, though the most common situation is the antrum, in which case it causes considerable enlargement of the body of the bone, encroaching upon the nasal fossae and the orbit, displacing the globe, and occasionally depressing the alveolar border. It may perforate the posterior wall of the antrum and enter the sphenomaxillary, zygomatic, or temporal fossa. It may enter the orbit from the direction of the sphenomaxillary fissure, or, finally, reach the cavity of the cranium through the foramen rotundum or the sphenoidal fissure. It may perforate the antrum at its anterior wall and involve the soft parts of the face. Projections into the nasal fossa are liable to ulcerate and give rise to sanious discharge and hemorrhage. Sarcomas involving the germ of the first permanent molar may occur in childhood. The disease is rare in infancy, however, occurring most frequently after the fifteenth year. As a rule, the sarcoma is of exceedingly rapid growth.

The mucous membrane of the **soft and hard palate** may be the seat of sarcomas, which may be mistaken for adenomas or endotheliomas. Melanotic sarcoma in this region is very rarely seen.

Sarcoma of the Alveolar Process; Epulis.—This originates from the external periosteum of the alveolar process. Epulis is characterized by a peculiar color, a mixture of blue, red, and brown. This is due to a brown pigmentation. Epulis is the only instance of pigmented sarcoma that is not exceedingly malignant. Microscopically the tumor is characterized by a very great number of giant-cells. Some specimens of the growth consist exclusively of giant-cells.

Epulis resembles, except in color, the ordinary fibroma of the gums. While the latter, however, may be removed by a simple incision involving only the gums, the former requires, in order to prevent recurrence, removal of a portion of the alveolus as well. If permitted to extend, the disease spreads in all directions and may finally require for its cure partial or complete resection of the upper or the lower jaw.

Sarcomas of the body of the jaw are of far greater malignity than the foregoing. They are observed usually between the fortieth and the fiftieth year of life. The disease appears most commonly in the body of the upper jaw as soft tumors of rapid growth. Microscopically they consist of small round cells in a scanty stroma. The antrum, orbital and nasal cavities are speedily invaded, and finally the ethmoid and base of the skull become involved in the disease. As they extend outwardly the skin of the facial region becomes involved, breaking down into ulceration.

The lower jaw may be attacked by sarcoma, where the latter may attain large proportions. It is less frequently observed here than in the superior maxilla, however. When it springs from the outer surface of the ramus it may be mistaken for a tumor of the parotid. The growth extends somewhat symmetrically. **Cystic sarcoma** also is found in this locality. Lymphatic glandular involvement is rare, and occurs at a late period and from septic processes, if at all.

Sarcoma of the jaw is liable to recur, even after the most careful resection of the bone. Exceptionally, in the case of the lower jaw, removal of the bone from the temporomaxillary articulation to the symphysis menti is followed by cure.

Carcinomas attack the alveolar processes of both jaws, particularly the lower. They may occur primarily from the gums, or secondarily from the adjacent soft parts. They are essentially a disease of advanced life. They tend to break down rapidly into ulceration, the teeth are loosened early and drop out, and the entire growth soon assumes the appearances of a foul ulceration with hard edges. The lymphatic glands at the angle of the jaw become involved early in the disease.

The only disease with which carcinoma is at all likely to be confounded is epulis. The latter, however, does not ulcerate early unless from being accidentally bitten. Lymphatic involvement is not the rule in epulis.

The body of the upper and lower jaw is rarely attacked by **primary carcinomas.** Malignant growths in this location belong, probably with rare exceptions, to the small-celled sarcomas. The absolute differential diagnosis depends on microscopic examination.

Patients with malignant disease of the jaw usually fall first into the hands of the dentist, and the disease is sometimes far advanced when it comes under the observation of the surgeon. Comparatively few cases are operated on early, and even these show marked tendency to rapid recurrence. Only the immunity, which rare and isolated cases enjoy, from a return of the disease justifies the surgeon in yielding to the importunate demands of the patient for operative interference.

RESECTION OF THE LOWER AND UPPER JAWS

This may be **partial** or **total.** In the former, removal of the processes or portions of the body of the bone is accomplished. In total resection all of the lower jaw, or half of the upper jaw, with its attached palate and malar bone, is removed. The inferior maxillary bone is seldom entirely removed.

Performance of the operation with the patient only **half anesthetized,** in order to prevent the blood from finding its way into the air-passages and producing suffocation, has been recommended. **Preliminary tracheotomy** with the

Fig. 310.—Rose's Dependent Head Position.

use of the **tampon cannula** (Trendelenburg) (Fig. 311) or a folded napkin crowded into the pharynx and occluding the glottic opening (Nussbaum) has also been employed for the same purpose. Nasal intubation and the tamponing of the pharynx (Crile, see page 304), or the slow raising of the patient to the sitting position after anesthetization (French), is preferable to either of these. Rose's dependent head position may also be employed with advantage (Fig. 310).

Resection of the Alveolar Processes.—Benign growths situated anteriorly, and even epulis, may be removed through the mouth without external incision. The operation is commenced by the removal of the teeth corresponding to the alveolar processes to be resected. Liston's forceps (Fig. 90, B) in the case of the lower jaw, and the chisel and mallet in the case of the upper jaw, are to be employed in making the necessary rectangular incisions. These incisions limit the part to be removed at each extremity of the growth. The portion between the rectangular incisions is freely separated from the lip and removed by means of the cross-cutting forceps (Fig. 312). In

carcinoma or **sarcoma** a free removal must be practised. In the case of the lower jaw it is best to remove the entire thickness of the body of the bone for a considerable distance beyond the limits of the disease.

Resection of Half the Lower Jaw.—The corresponding median incisor is extracted. The incision should, as far as possible, be placed below the border of the bone so that the resulting scar may be hidden. The lower lip is divided in the median line and the incision is carried downward to a

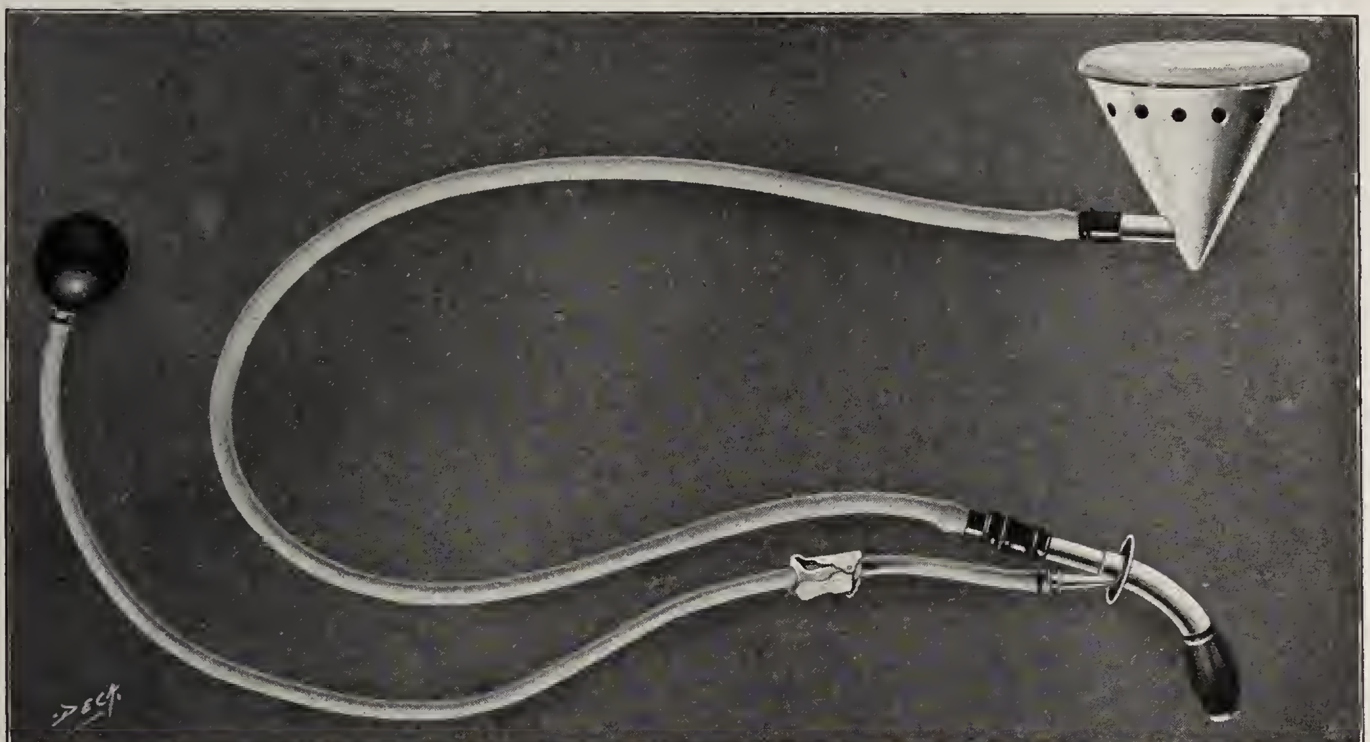


FIG. 311.—TRENDELENBURG CANNULA WITH ATTACHMENT FOR ADMINISTERING CHLOROFORM.

point below the level of the symphysis menti. The incision is then carried along just below the lower border of the bone as far as the angle, and then upward behind the posterior border of the ascending ramus to within $\frac{3}{8}$ of an inch of the lobe of the external ear (Fig. 313). The facial artery is divided and both ends at once secured. The incision terminates below the edge of the parotid gland, and the most important branches of the facial nerve are preserved. The tissues of the face and the masseter muscle are dissected

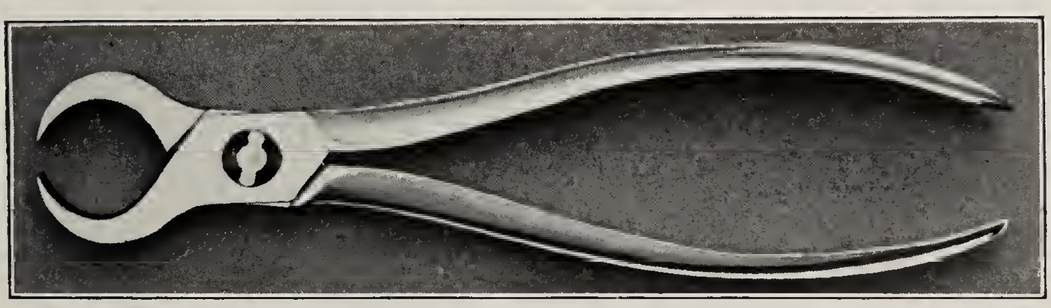


FIG. 312.—CROSS-CUTTING FORCEPS.

away from the bone or tumor, and the jaw sawed through at the symphysis with either a small frame saw or the Gigli wire saw. The tissues forming the floor of the mouth are divided by carrying the knife along the inner surface of the bone, care being taken to preserve the sublingual gland. The bone is now grasped by the lion forceps (Fig. 161) and the internal pterygoid muscle brought into view; the latter must now be detached. The jaw is now forced downward, the soft tissues held out of the way by means of retractors,

when the coronoid process is brought forward. The temporal muscle, which completely surrounds the latter, is now separated from the bone. It is sometimes extremely difficult to do this, owing to the unusual length of the process, or the fact that it is crowded against the malar bone by the bulk of the tumor. Under these circumstances it may be necessary to cut off the coronoid with bone forceps. After clearing the coronoid the jaw is still further depressed from before backward in order to throw the condyle forward; the parotid gland and masseter are held out of the way by means of retractors. As the coronoid becomes prominent the joint capsule, together with the ligaments and insertion of the external pterygoid muscle, alone remains to be divided. The first named may be divided by the knife, but the others are torn through in crowding the bone out of the glenoid cavity by forcibly depressing it. The muscular fibers are not to be divided with the knife, though the inferior dental nerve may require section, in order to prevent it from being dragged out of its bony canal. In executing the movement which depresses the jaw and forces the condyle forward, care should be taken not to rotate the jaw outward, else the internal maxillary artery will be torn or divided and give rise to troublesome or even severe hemorrhage. If rotation is avoided, the periosteum usually separates from the bone and both it and the artery are left behind intact.

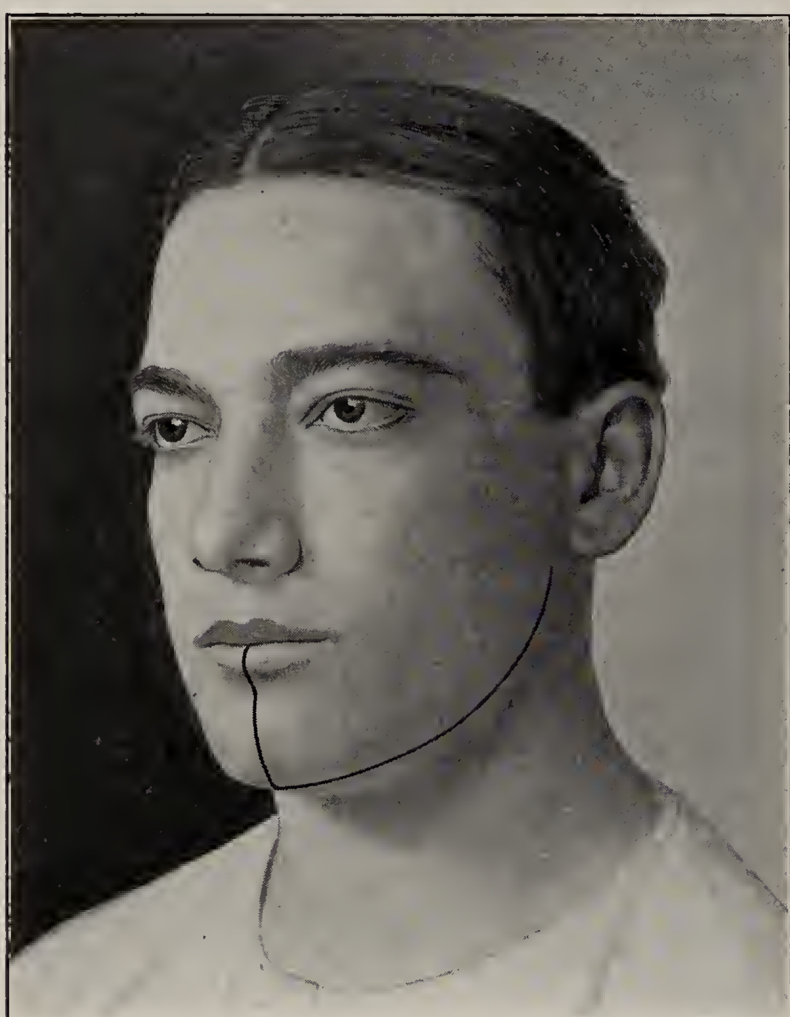


Fig. 313.—External Incision for Resection of Half of Lower Jaw.

All hemorrhage is to be arrested, and the oral cavity isolated from the remainder of the wound by a row of sutures uniting the edge of the mucous membrane of the cheek with that of the floor of the mouth. A row of external sutures is now applied, between which small openings for drainage are to be left. A drainage-tube is to be placed in the lower angle of the wound; this passes into the mouth and drains the oral cavity. Antiseptic dressings applied externally and frequent irrigation of the mouth constitute the after-treatment.

This procedure may be modified or varied on account of the growth of the neoplasm at the **central portion of the inferior maxillary arch.** Resection of the bone at this point involves the separation of the geniohyoglossus muscle of each side, which will permit the root of the tongue to fall backward and suffocation to occur. This is to be prevented by passing a silk ligature through the tongue. This part of the operation is given in charge of an assistant, and the tongue fastened by a strip of adhesive plaster to the cheek for the first few

days afterward. The head of the patient is held bent slightly forward as he lies on his side during the after-treatment, and on the first sign of suffocation the tongue is drawn forward.

Some discomfort arises from the failure of the teeth to approximate normally in mastication. In time this will be partially obviated by growth of new bone. A skilful dentist may be able to construct a frame of gold or silver wire for the purpose of maintaining proper separation of the remaining portions of the jaw, in order that the teeth may articulate properly with each other.

Removal of the entire lower jaw may be necessary in **phosphorus necrosis.** Under these circumstances the operation should be performed both subperiosteally and intrabuccally. In young subjects reproduction of the entire lower jaw may occur. If some months are permitted to elapse between the removal of the two halves (or the removal of the two jaws, as it is sometimes called), the periosteum becomes thickened and serves as a support for the portion last operated on.

Fig. 314.—Lines of Incision for Resection of the Upper Jaw.

Resection of the temporo-maxillary articulation is rarely required except for ankylosis of the jaw arising from inflammatory conditions in the neighborhood, or irreducible dislocation of the lower jaw. The head of the bone is exposed by an incision extending from the anterior margin of the zygomatic arch downward and $1\frac{1}{8}$ inches in front of the auricle. The soft parts are crowded away from the neck of the bone, the latter divided with the chisel and mallet, and the head of the bone removed. The proximity of the internal maxillary artery prohibits the use of the saw or bone-cutting forceps. A movable articulation is to be secured by early, persistent, and methodic movements of the jaw.

Resection of the Upper Jaw.—This is indicated in cases of malignant disease where the latter is limited to the upper jaw, and to gain access to nasopharyngeal tumors (**temporary osteoplastic resection**).

Operation (Fergusson, Weber).—The incisor teeth of the corresponding side are extracted. The incisions commence by dividing the upper lip in the median line. The incision continues on around the ala and thence on the side of the nose to the inner canthus of the eye (Fergusson). From this point it is carried along the infraorbital margin (Weber) and to the malar bone if necessary (Fig. 314). The flap thus marked out is dissected from the

FIG. 315.—RESECTION OF HALF OF THE UPPER JAW.
Dissection of the flap from the bone.

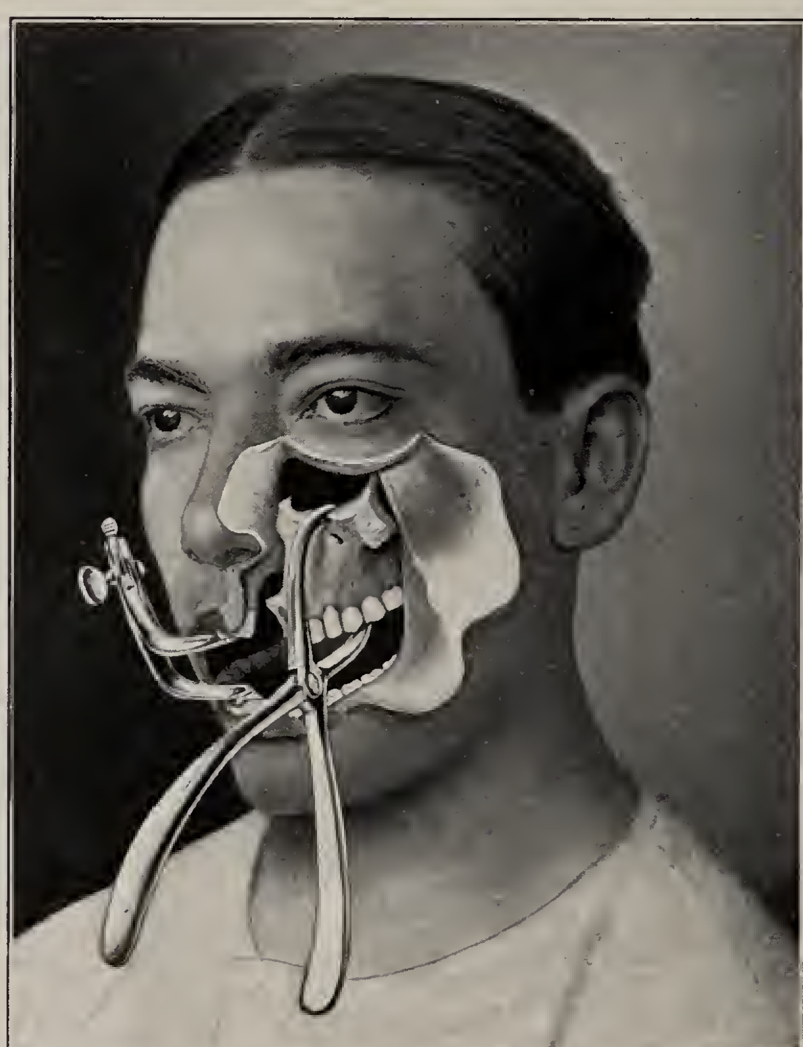


FIG. 316.—LION-JAW FORCEPS GRASPING THE RESECTED PORTION OF THE UPPER JAW.

bone (Fig. 315). A narrow saw is passed into the nostril and the alveolar process and hard palate are divided. The saw is now reversed and the nasal process of the bone divided in a direction upward and outward. The point of the saw is now carried along the thin floor of the orbit to the malar process or to the malar bone itself, if necessary, which is then sawed through. In benign tumors the orbital plate may be spared. These bone sections are completed with the bone-forceps. The mucous membrane of the roof of the mouth is now incised as far back as the soft palate in the line of the bone section. The bone is grasped with the lion forceps (Fig. 316), forcibly pried away from the pterygoid process and palate bone, and detached with the scissors from its remaining attachments to the soft parts (orbital fascia, infraorbital nerve, and soft palate). Hemorrhage is arrested by the ligature, the thermocautery, and packing with antiseptic (zinc oxid) gauze. The edges of the soft parts are adjusted by interrupted sutures of silkworm-gut.

Fig. 317.—The Lizar-Velpeau Incision Applied to Both Sides for the Simultaneous Removal of Both Superior Maxillas.

Septic complications are to be combated during the after-treatment by swabbing out the wound cavity with a 5 per cent solution of zinc chlorid at the first four or five redressings. Daily redressings, spraying with hydrogen dioxid, and irrigating the parts with a 1:1000 solution of permanganate of potassium or Thiersch's solution are necessary.

The dentist's art will materially aid in supplying the lost parts, both for **cosmetic** and **functional** purposes. **Visual disturbances** may occur from displacement of the globe.

Simultaneous removal of both superior maxillas has been performed for rapidly growing sarcoma, extending from one jaw to the other. This may be accomplished by means of the Lizar-Velpeau incision (Fig. 317) applied on each side. The entire facial soft structures of each side, including the upper lip, are dissected loose from the bone and turned up as one flap. Or, the Fergusson-Weber incision already described may be employed, applied on both sides. In this case two facial flaps are formed. The hard palate need not be divided. The saw is applied so as to divide the frontal process of one malar bone; thence it passes through the corresponding orbital plate and across the root of the nose; finally, it divides the orbital plate of the other side and the remaining malar bone.

Removal of both superior maxillas in two sittings is sometimes indicated in cases of **phosphorus necrosis.** The portion most advanced in disease is first removed. After several months the remaining jaw is removed.

THE NERVES OF THE FACIAL REGION

The nerves of the facial region are affected with neuralgia in the following order of frequency: (1) supraorbital; (2) inferior maxillary; (3) infraorbital; (4) frontal; (5) lingual.

Tic douloureux, or neuralgia of the fifth nerve accompanied by muscular spasm of the affected region, may be a symptom of peripheral nerve lesion, this being situated, as a rule, in a cicatrix of the alveolar margin. It is particularly liable to occur in the eruption of the lower wisdom tooth. In case the point of original injury and the consequent cicatrix can be determined, resection of the parts is indicated (see page 545).

Simple division of the branches of the trigeminus (**neurotomy**) at the point where they leave the bony canal is useless; relapse occurs in the vast majority of cases. In this connection, therefore, only those methods which are calculated to afford some hope of permanent relief will be considered.

Neurectomy of the Infraorbital Nerves and Superior Maxillary Nerve.—This nerve is attacked either at its place of exit at the infraorbital foramen, in the infraorbital canal, or at the foramen rotundum in the sphenomaxillary fossa, beyond the ganglion of Meckel. The infraorbital foramen corresponds to the upper limit of the canine fossa and is on a vertical line drawn directly upward from the fissure between the first and the second superior molar. A curved incision is made, parallel to the infraorbital margin and just below the latter; this separates the fibers of the orbicularis palpebrarum. On reaching the deeper portions of the canine fossa the fibers of the levator anguli oris are encountered, passing in a vertical direction. This muscle may be separated in the direction of its fibers, if not too thick; otherwise the latter may be divided. The leash of nerves arising from the division of the nerve-trunk as it emerges upon the face is now to be identified and dissected from the flap. The foramen may be readily found by following the nerve branches in a central direction. A $\frac{1}{2}$-inch trephine is now applied to the wall of the antrum of Highmore with its edge just below the foramen, or the wall may be chiseled away. Access is thus gained to the antrum. A V-shaped piece is to be chiseled away from the margin of the orbit at the site of the foramen, the nerve-trunk loosened, and $\frac{1}{4}$ inch or more removed at this point. To resect the **superior maxillary nerve** the trunk is followed along the infraorbital canal, the walls of the latter being chiseled away for that purpose. A head band mirror reflecting light into the antrum will be useful at this stage of the operation. The posterior wall is perforated with a $\frac{3}{8}$-inch trephine, with its point withdrawn, and the sphenomaxillary fossa entered. Hemorrhage is to be arrested by pressure and section of the nerve made by means of double curved scissors close to the edge of the foramen rotundum. The resected portion of nerve is withdrawn and the thermocautery applied, if the hemorrhage persists in the fossa. This serves also to effect destruction of the ganglion of Meckel, and the palatine nerves passing thereto. The cavity is to be packed and the external wound partially closed by suturing.

Method by Means of Temporary Resection of the Malar Bone.—This method, introduced by Lücke, of Strasburg, is as follows: An incision is made from the middle of the external orbital edge downward and

toward the median line, terminating near the root of the third molar. This is carried down to the bone. The malar bone is freed from periosteum at both its anterior and its posterior surface, and a chain saw passed. The bone is now divided from behind, forward and inward. A second incision begins at the lower angle of the first, is carried to the lower edge of the malar bone, and thence to the junction of the zygomatic arch and the temporal bone. The zygomatic arch is separated by means of a chisel or the cutting bone forceps. The insertion of the masseter at the malar bone is detached, when the entire flap, consisting of bone and soft parts, is turned upward by means of retractors. By displacing outwardly the temporal muscle, the infraorbital fissure is reached and resection of the nerve performed at this point. On account of injury of the masseter, which interferes afterward with opening the mouth, it has been proposed (Lossen, Braun) to carry the horizontal incision of Lücke above instead of below the malar bone. Avulsion of the nerve may be performed (Thiersch), or twisting and avulsion combined (Braun), through either of these incisions.

Neurectomy of Second and Third Divisions of the Fifth Nerve with Avulsion of the Gasserian Ganglion.—An omega-shaped incision is made having its base at the zygoma and measuring a distance marked by a line drawn from the external angular process of the frontal bone to the tragus. The curved upper portion reaches to the supratemporal ridge. An osteoplastic resection of the bone is made by chiseling a groove on the same lines, the bone breaking at the base of the omega and the soft parts serving as a hinge to the trapdoor-like flap which is turned down. The dura and brain are raised from the floor of the middle fossa of the skull by retractors, and both the foramen rotundum and ovale exposed, together with the second and third divisions of the fifth nerve. By forcing back the dura at the front where the second and third divisions of the fifth nerve pass through the foramen rotundum and the foramen ovale, these branches are divided close to the bone. The central ends of the divided nerves are grasped by forceps and excised or avulsed to a point beyond the Gasserian ganglion. The osteoplastic flap is now replaced and united by sutures (Krause, Hartley).

Various modifications of the above method have been introduced. The best of these is that of intracranial neurectomy devised by Abbe, in which a vertical incision over the middle of the zygoma and the removal of sufficient of the temporal bone to give access to the site of the Gasserian ganglion replace the omega-shaped osteoplastic flap of Krause and Hartley. The second division is resected at the foramen rotundum and the third division at the foramen ovale. In order to prevent reunion of the divided nerve-trunks a piece of sterilized rubber tissue is implanted over the foramen ovale and the foramen rotundum after resection of the nerves (Fig. 318).

The following points should be borne in mind in conducting the operation: (1) The incision should be of sufficient length to permit easy retraction of its edges. (2) The soft parts, including the periosteum, should be well cleared to and somewhat below the level of the zygoma. (3) The preliminary trephine opening should be immediately opposite the foramen ovale. This will be on a line drawn vertically from just in front of the condyle of the lower jaw. (4) In enlarging the opening with the gouge forceps this should be confined as much

as possible to the squamous portion of the temporal bone. Encroachment upon the area beyond this is sometimes followed by troublesome hemorrhage from the vessels in the diploe. If this is unavoidable, however, the flow of blood may be usually arrested by grasping the edge of the bone at the site of the bleeding by a rongeur forceps and crushing the diploe. (5) In separating the dura from the base this should be done by the finger. The separation should be carried on systematically and continuously without regard to the hemorrhage until the finger encounters the flattened out trunk of the third division, which is usually easily recognized by the touch at the foramen ovale. The brain is then lifted from the base of the skull by the retractor (either Hartley's or the one shown in the illustration, see Fig. 318), the blood cleared away by rapid sponging, and the parts thoroughly packed with iodoform gauze. This is removed and replaced at intervals of five minutes or less until the bleeding ceases. (6) The third division at the foramen ovale is first caught up by a blunt hook and drawn out as far as possible. The nerve is then grasped by a narrow bladed forceps on the foramen side of the hook and divided between the two, as close to the ganglion as possible. By traction on the peripheral stump by means of the forceps, from an eighth to a quarter of an inch of the nerve-trunk is dragged out of the foramen and removed. The second division at the foramen rotundum is dealt with in the same manner. (7) Under no circumstances should the pressure exercised by the retractor in lifting the brain from the base of the skull be kept up for more than two or three minutes at a time, on account of the damaging effects of the compression on the cerebral substance, and of the prolonged displacement of the cerebrospinal fluid. The respiratory center is especially likely to be unfavorably influenced by the latter, as shown by the shallow breathing of the patient.

Fig. 318.—Abbe's Intracranial Neurectomy.

Neurectomy of the Inferior Dental Nerve.—The nerve is to be reached at its entrance into the bony canal. The nerve lies about in the middle line of the jaw, except in old people, when it lies more inferiorly. It enters the bone about $\frac{3}{8}$ of an inch above a line drawn from the point of the projecting angle of the jaw to the center of the receding angle within the cavity of the mouth.

In order to expose the nerve a flap is formed, with its base upward, its sides corresponding to the anterior and posterior edges of the ramus of the jaw. The masseter attachment, together with the periosteum, is separated and the surface of the bone exposed. A portion of the bone is chiseled away, or the trephine is applied and a button of bone removed; the bone is further chiseled

away in an upward direction. The nerve can scarcely be separated from the artery, and therefore both are generally severed. A piece of the nerve is resected and the hemorrhage arrested by pressure. If the themocautery is employed in the section, hemorrhage is avoided (H u e t e r). The flap is replaced and sutured.

Methods without Chiseling the Bone.—An incision is made along the posterior edge of the ramus of the jaw down to the periosteum, which is lifted. The internal pterygoid insertion is divided with scissors. The spine of Spix is identified by means of the index-finger, and with the latter as a guide the nerve is hooked at the point at which it enters the inferior dental foramen. The nerve is drawn out into the external wound without being divided, after which an inch or more may be resected. Or the same result may be obtained by an incision along the angle of the jaw (S o n n e n b u r g).

In the first mentioned method the cosmetic effect is inferior to that of the second. On the other hand, in the two last mentioned methods the division of the pterygoid constitutes an objection from the point of view of function.

In some cases in which intractable neuralgia persists after resection of the inferior dental nerve, it will be necessary to reach the third division of the fifth pair at its exit from the foramen ovale, or this may be performed at the outset.

Intrabuccal Methods.—The mouth is opened widely and the coronoid process identified. The mucous membrane is incised at this point from above downward, the soft parts pushed away from the bone, and the spine of Spix felt for with the index-finger. The nerve is then hooked up and resected. Only a small portion can be removed by this method, and a pocket for the accumulation of pus is left.

Method by Temporary Resection of the Lower Jaw.—The jaw is exposed by an incision commencing in front of the mastoid and extending first downward along the sternomastoid to the cornu of the hyoid bone, and from here upward and forward until it reaches the point of insertion of the masseter. The bone is divided just posterior to the last molar by means of a G i g l i saw, the internal pterygoid muscle severed, and the two halves of the jaw reflected; the cavity of the mouth should not be opened. The process of Spix is now to be identified; just below this short spine and posterior to it the nerve enters the dental canal. Here it is hooked up and secured by passing a thread around it. It is now divided close to the bone and drawn out with the thread so that it can be followed up to the foramen ovale. The chorda tympani is to be avoided. After section of the nerve at the foramen ovale it will be found still held by its gustatory branch passing to the tongue. The point where the chorda tympani joins the gustatory should be identified and the latter severed *above* this. The jaw is to be wired and the wound closed except where the wire emerges.

In order to secure proper articulation of the teeth the services of a dentist should be employed to make an interdental splint before the section of the jaw is made. This is to be employed in the after-treatment.

Method by Temporary Resection of the Malar Bone (S a l z e r).—A curved incision with its convexity upward extends along the entire length of the malar bone. The skin, fascia, periosteum, and temporal muscle are divided. The bone is divided at each end and the temporal muscle loosened

from the skull. The flap, consisting of the skin, muscle, and bone, is now retracted downward. The nerve is separated from the middle meningeal artery, divided close to the foramen and a portion resected. The coronoid process of the inferior maxilla is kept out of the way by opening the mouth widely. The vessels in the pterygoid fossa lie beneath the field of operation, and the external pterygoid muscle is uninjured. The parts are to be replaced and sutured as in Lücke's operation (page 540).

Method without Bony Resection.—The incision is carried in a curved direction from $\frac{5}{8}$ of an inch above the angle of the jaw to a point in front of the facial artery, where the latter crosses the bone. The parotid gland is loosened from the parotido-masseteric fascia and retracted in an upward direction. The internal pterygoid muscle is separated at its insertion at the angle. The guide to the nerve is the spine of Spix (Ullmann).

Neurectomy of the Supraorbital Nerve.—Neuralgia of this nerve occurs next in frequency. It is sometimes the result of an inflammatory swelling of the periosteum lining the short canal in which it lies at the supraorbital ridge.

An incision is made, following the line of the supraorbital ridge. The skin and orbicularis palpebrarum are separated from the bone, as well as the external portion of the superior tarsal cartilage. By pushing back the fat and connective tissue in the orbit the roof of the latter is brought into view. The nerve is now isolated from the adipose and connective tissues, when a piece $1\frac{7}{8}$ inches long may be removed. The wound may be sutured in its entire length; primary union is the rule.

Intraneural injections of osmic acid have been employed in intractable facial neuralgia (Bennett). Temporary relief may be sometimes obtained by this method, lasting for months, and exceptionally for longer periods of time. The method is indicated in the aged and in those in poor physical condition. A general anesthetic may be administered, or local anesthesia may be secured, and the branches of the fifth nerve exposed. In the case of the supraorbital nerve the incision is made over the supraorbital notch and parallel with the eyebrow. The infraorbital is reached most easily by a curved incision at the site of the infraorbital foramen. To avoid deformity, however, the nerve should be reached, whenever possible, by forcible retraction of the upper lip, incision of the mucous membrane of the mouth and dissection of the structures covering the superior maxilla. The mental branch of the inferior dental is reached at the mental foramen by retraction of the lower lip and an incision through the mucosa.

The nerve is elevated by a blunt hook, and from 5 to 15 minims of a freshly prepared 1.5 per cent solution injected directly into the nerve by means of an ordinary hypodermic syringe and fine needle. The solution is injected in several places, in order to be certain that every portion of the nerve is reached, and finally a small quantity is injected between the nerve and its sheath in its bony canal (J. B. Murphy).

The *modus operandi* of the procedure is not definitely understood. It should not be employed in neuralgias of nerves with important motor functions.

Neurectomy of the Lingual Nerve.—Except for the purpose of relieving the pains of inoperable carcinoma of the tongue, this nerve rarely requires division, compared with the frequency with which the second and third divisions of the trigeminus are operated on.

For **neuralgia** the lingual nerve may be readily reached by an incision at the lateral edge of the tongue. C. Hueter was compelled to perform a neurectomy of the lingual for intractable neuralgia following a wound of the tongue by a common table fork. In **carcinoma** of this organ, however, the nerve must be reached at a higher point. This may be accomplished by the same incision recommended for neurectomy of the inferior dental, and by chiseling away a portion of the receding angle of the inferior maxilla until the spine of Spix is reached. The nerve is here hooked up and resected.

Neurectomy and Stretching of the Facial Nerve.—Painful spasm of the face (tic douloureux) sometimes requires operative interference. The disease is characterized by continuous convulsions of the facial muscles of one side. In some cases the spasm is of reflex origin and depends on increased sensibility of the branches of the trigeminus. Resection of the nerve is necessarily followed by paralysis of the facial muscles of the corresponding side. Stretching of the nerve is the preferable operation and should be first tried.

The nerve may be reached through an incision at the anterior edge of the sternomastoid insertion. The body of the parotid gland is drawn toward the front by blunt retractors; the styloid process is the guide to the nerve at its point of exit from the stylomastoid foramen.

Hueter's Method.—The lobe of the ear is separated from the facial skin by a vertical incision 2 inches long at the posterior edge of the ramus of the jaw. The parotid fascia is divided and the parotid gland separated, care being taken not to invade the region behind the ramus, where the external carotid artery may be wounded. By careful dissection the inferior branch is reached first, which, though very small, may be recognized by its curve as it passes anteriorly. Following this the superior branch is found, passing almost horizontally and meeting the first at an acute angle. The main trunk is now followed to the stylomastoid foramen.

The nerve may be **stretched,** without being followed to the foramen, from the point of union of the upper and the lower branch. The paralysis which follows stretching may be recovered from; the original spasm frequently returns at the same time.

Mimic spasm consists of continuous convulsive movements of the facial muscles of one side, particularly of the orbicularis palpebrarum. A more or less constant winking occurs. The convulsions are usually of reflex origin and depend on an exaggerated irritability of the sensitive branches of the trigeminus nerve, which are usually very sensitive to touch, as well as painful. Pressure on a sensitive branch at its place of exit at once arrests the spasm. Surgical treatment will sometimes give relief. This consists in a neurectomy of the branch involved.

THE TONGUE

Examination of the Oral Cavity.—The ordinary tongue depressor is used by daylight for purposes of **inspection.** For examination in a dark room, or at night, the combined tongue depressor, candlestick, and reflector, or the electric light tongue depressor, is useful (Figs. 319 and 320). The cheek may be retracted by the finger placed in the angle of the mouth. Special oral specula are rarely necessary for purposes of examination.

Palpation of the organs behind the line of the teeth (tongue, hard and soft palate, and tonsils) is of value in cases of suspected syphilitic, tuberculous, or carcinomatous disease of these organs, and should never be omitted.

Lacerated wounds of the tongue from violent contact with the edges of the teeth occur during careless mastication, from falls on the chin

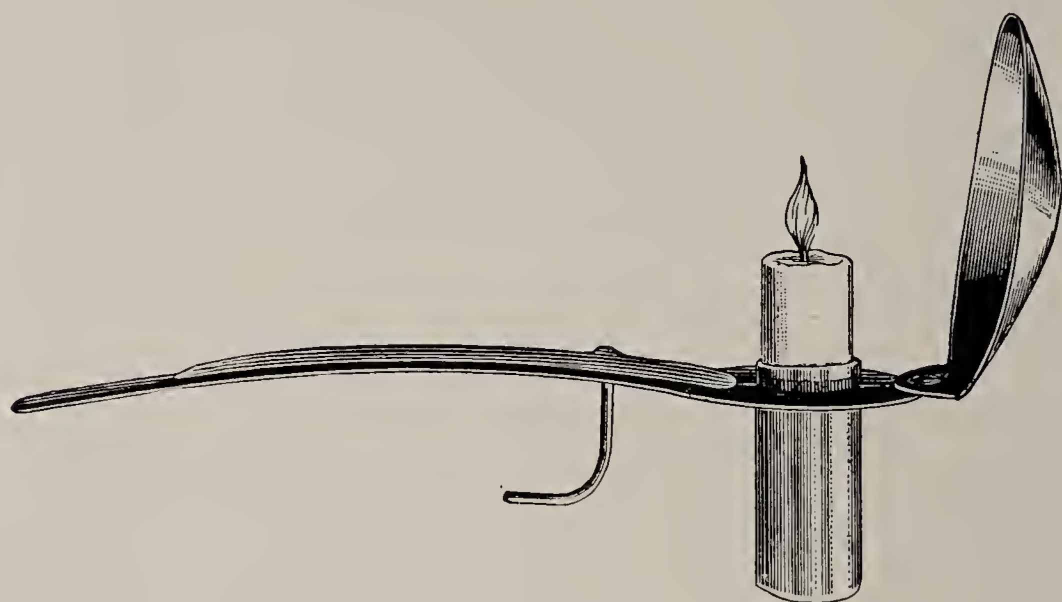


Fig. 319.—Combined Tongue Depressor, Candlestick, and Reflector.

with the tongue projecting between the teeth, and in epileptic convulsions. **Punctured wounds** occur from the presence of bone splinters, bits of glass, needles, etc., in the food. **Gunshot wounds** of the tongue may occur in connection with simultaneous injury of the bone, or the missile may enter the cavity from the suprahyoid region, the head being forcibly extended. **Burns** and **scalds** of the tongue are comparatively frequent but not likely to be severe.

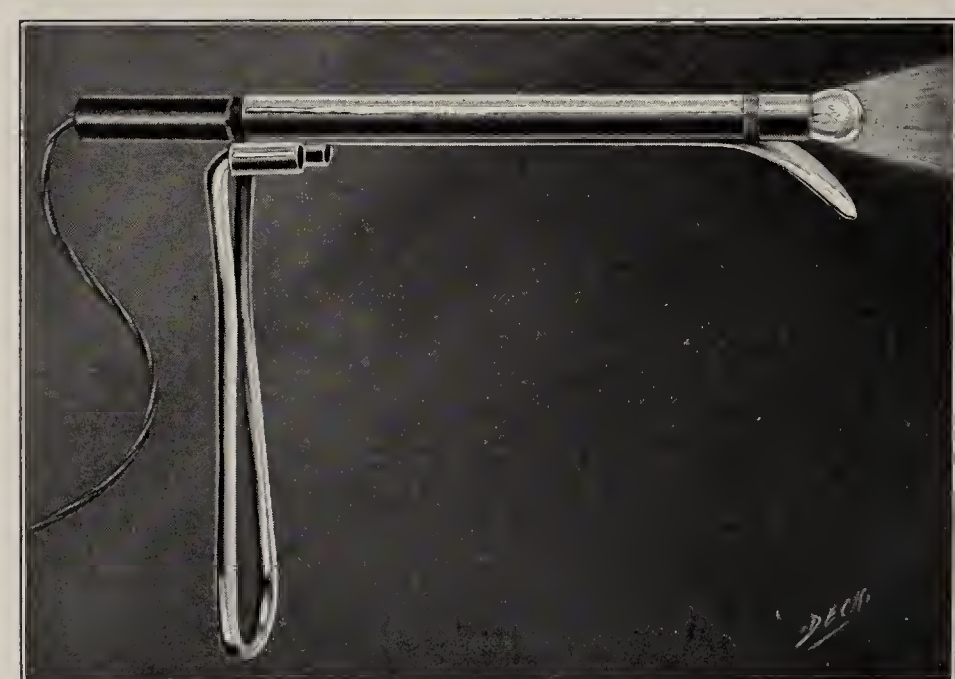


Fig. 320.—Electric Light Tongue Depressor.

Treatment.—These injuries of the tongue are neither difficult of management nor dangerous to life. The hemorrhage, which may be considerable, is usually arrested by a few deep sutures. Pain, which may be severe, is to be allayed by small pieces of ice in the mouth. Suturing is facilitated by passing a loop of thread through the organ at its tip and pulling it forward. In consequence of the rich blood-supply, healing usually takes place by primary union.

Inflammatory edema usually marks the limit of the reaction following traumatism of the tongue. The vital resistance of the organ is very high, and hence marked septic processes, such as phlegmonous inflammation, or suppuration extending beyond the wound surfaces themselves, are rare. In slight

injuries healing may take place without any apparent reaction whatever. In those rare cases in which the swelling in traumatic glossitis is such as to embarrass respiration, **scarification** may be necessary, the branches of the lingual nerve at the lateral aspects being avoided, and the knife being entered slowly and superficially to avoid the branches of the lingual artery.

Ulceration occurs on the lateral aspect of the organ from contact with the sharp edges of a tooth, and disappears on the removal of the latter. A simple **localized glossitis** may arise from the same cause.

Chronic Glossitis.—This includes a number of affections, the important characteristic of which is a change of form and overgrowth of the epidermis, or **keratosis.** Epithelioma is prone to develop during these changes.

Leukoplakia (**leukokeratosis**) is a name given to the white patches on the tongue and buccal mucous membrane, the result of **keratosis** or cornification. The disease has its origin in a long-continued chronic glossitis. The gouty and rheumatic diathesis, irritative changes from syphilis, and smoking are thought to favor the development of the affection.

Symptoms.—The patient frequently is not aware of the presence of the disease in the beginning until the peculiar appearance of the tongue is discovered by accident. As the disease advances there may be burning or smarting when hot or highly spiced food is taken. Later on, the cornification becomes thick and unyielding and gives rise to considerable discomfort and to more or less interference with the movements of the tongue. The sense of taste is affected in proportion to the thickening of the coating and its area. The affection is found on the buccal mucous membrane, and particularly on the lining of the lower lip and near the angles of the mouth. The patches vary from time to time in size and shape, and in their location on the tongue as well.

Of the varieties of leukoplakia the most important are (1) so-called **syphilitic psoriasis**; (2) **smoker's patch**; (3) **simple psoriasis**; (4) **ichthyosis**, an advanced stage of the affection in which the papillae are greatly hypertrophied, giving the tongue a warty appearance.

The **diagnosis** is usually not difficult. The chronicity of the affection, its almost exclusive occurrence in male adults, and the bluish-white tint of the patch are sufficient to distinguish it.

The **prognosis** is unfavorable for complete cure. In addition, the disease offers a predisposing cause of cancer. The latter may develop after the leukoplakia has been in existence for many years.

The **treatment** consists of abstention from all foods and drinks which tend to produce irritation. The use of tobacco, particularly chewing tobacco, must be forbidden when the patches are spreading. Alcoholic drinks, if taken at all, must be largely diluted. Leukoplakia of syphilitic origin is not usually benefited by antisyphilitic treatment. It is a postsyphilitic, not a syphilitic, manifestation. Alkaline mouth-washes, such as a 20-grain solution of bicarbonate of potash, give the greatest relief as a rule. Solutions of chlorate of potash, and hydrogen dioxid are useful. Syphilitic cases are benefited most by applications of a 10 grain to the ounce solution of chromic acid. A mouth-wash of the same in about one-fifth of the above strength may be used. The patches may also be touched with a 10 per cent solution of potassium iodid. Cold cream containing borax or eucalyptus acts favorably by pro-

tecting the surface. All sources of irritations within the mouth, such as ragged or decayed teeth, should be removed. If ulcers or fissures form, total excision of the affected parts is to be recommended. In advanced cases, and because of the dangers of the supervention of malignant disease, destruction of the cornified area with the thermocautery is advisable (V o l k m a n n).

Tuberculous ulceration of the tongue may accompany pulmonary tuberculosis or occur primarily. It is usually situated at the tip near the lateral margin and is more frequently observed in men than in women. It may be mistaken for carcinoma. Extirpation is indicated in both cases. The diagnosis may be established by microscopic examination of a portion removed for the purpose. **Lupus** of the tongue is very rare.

Abscesses of the tongue are usually the result of a breaking down of gummas. They are situated in the median line, and as a rule pursue a chronic course. If far advanced, the usual antisyphilitic treatment of iodid of potassium must be supplemented by incision and curettage.

Fig. 321.—Macroglossia.

Nonsyphilitic phlegmon (erysipelas of the tongue) is comparatively rare. It is sometimes ushered in by chills and vomiting. The sweating may be considerable, as in traumatic glossitis, and finally subside, or eventuate in abscess. Early opening of the latter is indicated. Scarification is useful in any event.

Deformities of the Tongue.—The most important of these is the congenital giant growth (**macroglossia**). This occurs (1) as a **fibromyoma,** the muscular structure and connective tissue being abnormally developed; (2) as a **lymphangioma,** the vessels proliferating into the spaces. The tongue may be so large as to project from the mouth from want of space, and hang down as a dry, fissured, or ulcerated mass, which bleeds easily (Fig. 321). The incisor teeth become loosened and crowded forward to a horizontal position. An acquired similar condition following **erysipelas of the tongue** suggests an analogy to elephantiasis following erysipelas of a lower extremity. The **treatment** consists in excision of wedge-shaped portions at successive sittings, to avoid profuse hemorrhage. Pressure by means of flat-bladed forceps behind the incisions will control the bleeding until deep sutures can be taken. Puncture by means of the thermocautery has been used successfully (H e l f e r i c h).

Congenital ankyloglossia or tongue-tie is a very rare condition. When present, it is due to a defective development of the tongue, rather than to an excessive development of the frenum. The condition will, with rare exceptions, correct itself with the growth of the child. Where the tongue-tie indubitably interferes with sucking, it may be corrected by lifting the tongue

with the index-finger and cutting the tense fold of mucous membrane close to the floor of the mouth with blunt scissors. Excessive bleeding is to be prevented by putting the child to the breast at once. Fatal hemorrhage has occurred after division of the frenum. Death from asphyxia, due to tongue-swallowing (Petit) and macroglossia, has also followed this operation (Sédillot, Döllinger).

Bifid or split tongue consists of a longitudinal fissure which divides the forepart of the tongue into two unequal parts. The split may extend a considerable distance toward the root. It may be associated with a cleft lower lip, with arrest of development of the lower jaw, and cleft palate or harelip. The opposed surfaces may be pared and brought together with sutures.

Acquired ankyloglossia is the result of cicatricial thickening of the frenum following ulceration occurring in the course of the eruption of the incisors. The mucous membrane on each side of the frenum becomes irritated by contact with the sharp edges of the teeth as they first appear. Later on, as the teeth advance, the pressure ceases and the ulceration heals, leaving the frenum contracted. The treatment is the same as in congenital tongue-tie.

Cancer of the Tongue.—This occurs most frequently after the fortieth year. Among 4600 cases of cancer collected by Jessett, over 8.7 per cent were cases of cancer of the tongue. This relative frequency is explained by the exposure of the tongue to various sources of irritation. The proportion of men to women attacked is 85 per cent. This is attributed to the habit of smoking, though the rôle which the latter plays in the causation is probably exaggerated. Its occurrence is commonly ascribed to friction against a carious tooth with rough edges. The most common location for its first appearance is on one or the other side of the tip; it is occasionally observed on the dorsum, but it is never found in the median line of the organ. Leukoplakia, syphilitic ulcer, and ichthyosis are noted as of rather frequent occurrence precedent to epithelioma of the tongue.

Lymphatic glandular infection occurs early, dissemination is not common, and death frequently takes place within a year.

The disease occurs in the **ulcerative** and the **infiltrated** forms. The former involves rapid destruction, while the latter is characterized by the appearance of nodules varying in size from a pea to a hazelnut, which appear deeply embedded in the muscular substance of the organ along its lateral margins. These finally ulcerate, after which the progress is very rapid, the disease extending in all directions.

Symptoms.—There is a large increase of the saliva from reflex irritation of the salivary glands. **Decreased mobility** of the tongue, **difficult deglutition,** and **embarrassment of speech** are prominent features. **Pain** is marked. It occurs early in the disease, is radiating in character, and is propagated from the lingual branch of the inferior maxillary division of the fifth nerve to the other sensory branches of this division (auriculotemporal and inferior dental). Violent pains are complained of in the **external auditory meatus** and the temporal and submaxillary regions of the affected side.

The patient is liable to fatal hemorrhage from the lingual or carotid artery, or life may be destroyed by septic pneumonia, asphyxia from edema of the glottis, the pressure of massive cervical glands on the trachea, or from septicoanemia, exhaustion, and semistarvation combined.

The **prognosis** is doubtful at best. It is most favorable if removal is accomplished before lymphatic involvement. The mortality after operation is 10 per cent, the causes of death being hemorrhage and septic pneumonia. The liability to recurrence is very great. The latter takes place in the stump or in the cervical glands within a year. In cases otherwise inoperable neurectomy of the lingual nerve will relieve the pain and excision of both external carotids and their branches (D a w b a r n) may serve to hold the disease in check.

Diagnosis.—The character of the pains and their distribution are of diagnostic importance. The ulcerative variety may be mistaken for **syphilitic ulcer** and the infiltrated variety for **gumma.** In the former, induration of the lingual substance will be less marked than in carcinoma; in the latter, the nodules will occupy the median portion of the tongue and there will be an absence of the characteristic pains. If no impression is made on the growth in fourteen days by the internal administration of iodid of potassium and inunctions of mercurial ointment, carcinoma is to be suspected and a section removed for microscopic examination. **Tuberculous ulceration** rarely occurs without the presence of other tuberculous foci.

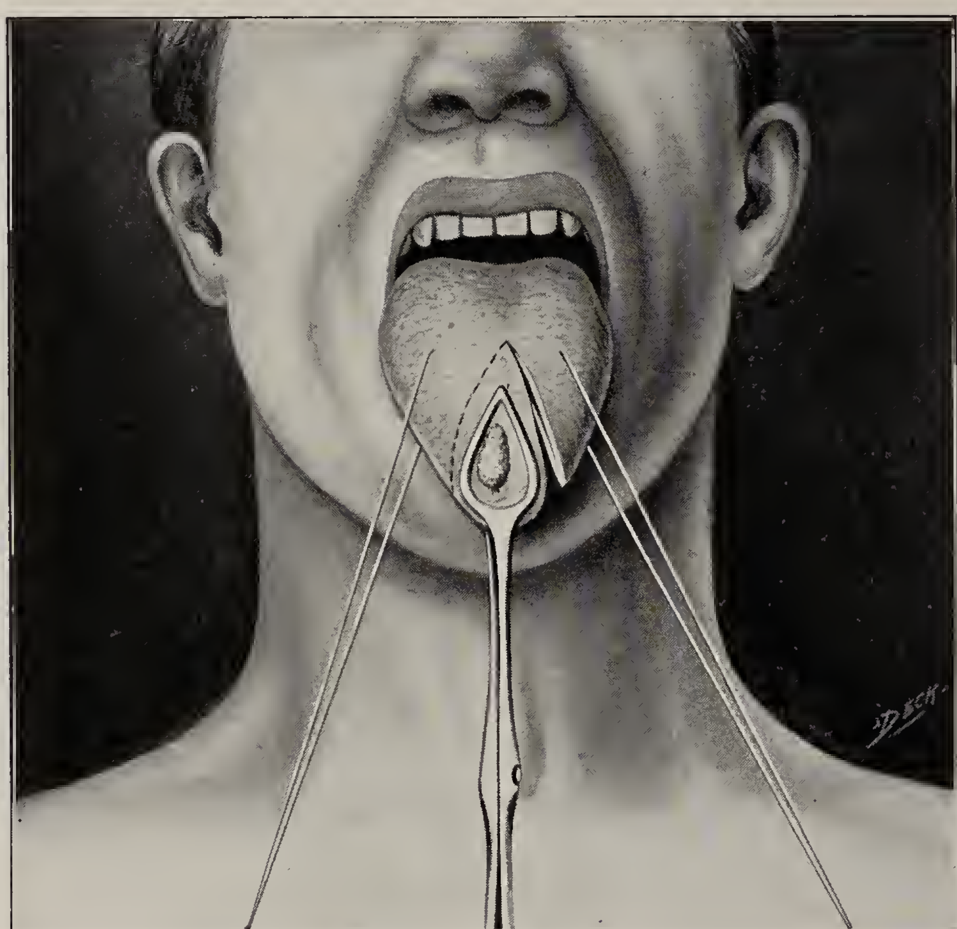


Fig. 322.—V-shaped Excision of Tip of the Tongue.

The Operative Treatment of Carcinoma of the Tongue.—The exceedingly rapid course which carcinoma of the tongue pursues, as well as the early lymphatic involvement, demands prompt operative interference. Above all things, the application of nitrate of silver or other caustic substances is to be avoided. Such applications involve loss of time and favor further growth by their irritating effects.

When the disease is superficial and situated near the tip of the tongue, a large cuneiform piece may be excised. The entire organ should be drawn well forward by two stout ligatures passed well back at the base (Fig. 322). The part to be removed is grasped by forceps, the frenum divided, the entire tongue brought well forward, and a V-shaped piece excised. On account of the tendency to **focal proliferation,** the limits of the portion to be excised should be first marked out on the mucous membrane of the dorsum of the tongue with a scalpel, from a fourth to three-eighths of an inch of healthy tissue being included. The gap left after the excision should be sutured at once. If a large portion is to be removed the sutures may be passed preliminarily.

In the average case, however, nothing short of **extirpation of half of the tongue** will suffice in indubitable cancer of the organ. In still more advanced cases, with extensive ulcerative carcinoma, or deep nodular infiltration, **total extirpation** will be required. When the floor of the mouth is involved and lymphatic glandular involvement present, the operation must be extended so as to include these.

In cases otherwise inoperable the removal of a portion of the **lingual nerve** will serve for a time to arrest the pain. Excision of the external carotid artery on each side for the purpose of inhibiting the growth of malignant disease in the area of distribution of this vessel has been followed by encouraging results in the hands of the originator of the method, Prof. Dawbarn.

The Hemorrhage.—When the whole tongue is to be removed, one or both lingual arteries may be tied primarily. When carcinomatous glands in the neck are to be removed, this should be done before the tongue is excised, and the linguals tied at the same time, provided the wound in the neck does not communicate with the cavity of the mouth. Otherwise the linguals should be tied as they are divided, owing to the septic complications which are likely to ensue and the consequent dangers of secondary hemorrhage.

Asphyxia from the passage of blood into the trachea is one of the dangers to be feared. Whitehead prevents this by placing the patient in a semisitting position with the head held forward. The Trendelenburg position, as adopted by Keen for laryngectomy, or Rose's hanging head position for cleft palate operations, serves a useful purpose in severe cases. The venous oozing is increased by these measures, however. In the majority of cases the patient may be placed on the side with the angle of the mouth firmly pressed down by an assistant. **Preliminary tracheotomy,** or, better still, **laryngotomy** (Bond, Butlin), should be performed when the entire tongue is to be removed.

Whitehead's Operation for Extirpation of Half of the Tongue (**Modified**).—The mouth should be washed out with antiseptic solutions for a few days prior to the operation and all loose or carious teeth removed. The head should be somewhat elevated on a sand-bag and turned to one side. Whitehead operates with the patient's head elevated and bent forward. The mouth is held open by a self-retaining mouth-gag. Chloroform should be administered by means of a Junker's inhaler with a nasal tube. A stout ligature is passed through the base of the tongue on the sound side and another through the tip on the diseased side (Fig. 323). The operator grasps the latter and the former is given in charge of an assistant. When the disease does not encroach upon the floor of the mouth, the tongue is split at once along the raphe to the base by first cutting through the mucous membrane on the upper and lower surfaces and then forcibly tearing the two halves apart. The diseased half is extirpated by first dividing the attachments to the floor of the mouth, then the anterior pillar of the fauces, and finally making a transverse section well behind the limits of the growth. The lingual artery is secured either before or after the transverse incision is completed.

When the disease encroaches upon the floor of the mouth, the frenum is first cut through well in front of the limits of the growth. The incision is now extended along the tongue laterally, still well outside the diseased area, until

the anterior pillar of the fauces is reached, when the latter is divided. The diseased half is now brought well forward, the tongue split in the middle line, and the muscular structures on the floor of the mouth cut through. When the floor of the mouth is deeply affected, the sublingual gland is removed. The lingual artery is secured, and, finally, the half of the tongue removed by a transverse incision with the scissors.

In order to control the bleeding from the floor of the mouth gauze sponges are pressed on the wound surface and counter-pressure made with the hand beneath the chin. After the vessels are secured and the mouth cleansed the latter is sponged out with a zinc chlorid solution (40 grains to the ounce). The mucous membrane on the dorsum of the tip is secured to that on the under surface by sutures, in order to prevent the tip from being bound down in the floor of the mouth.

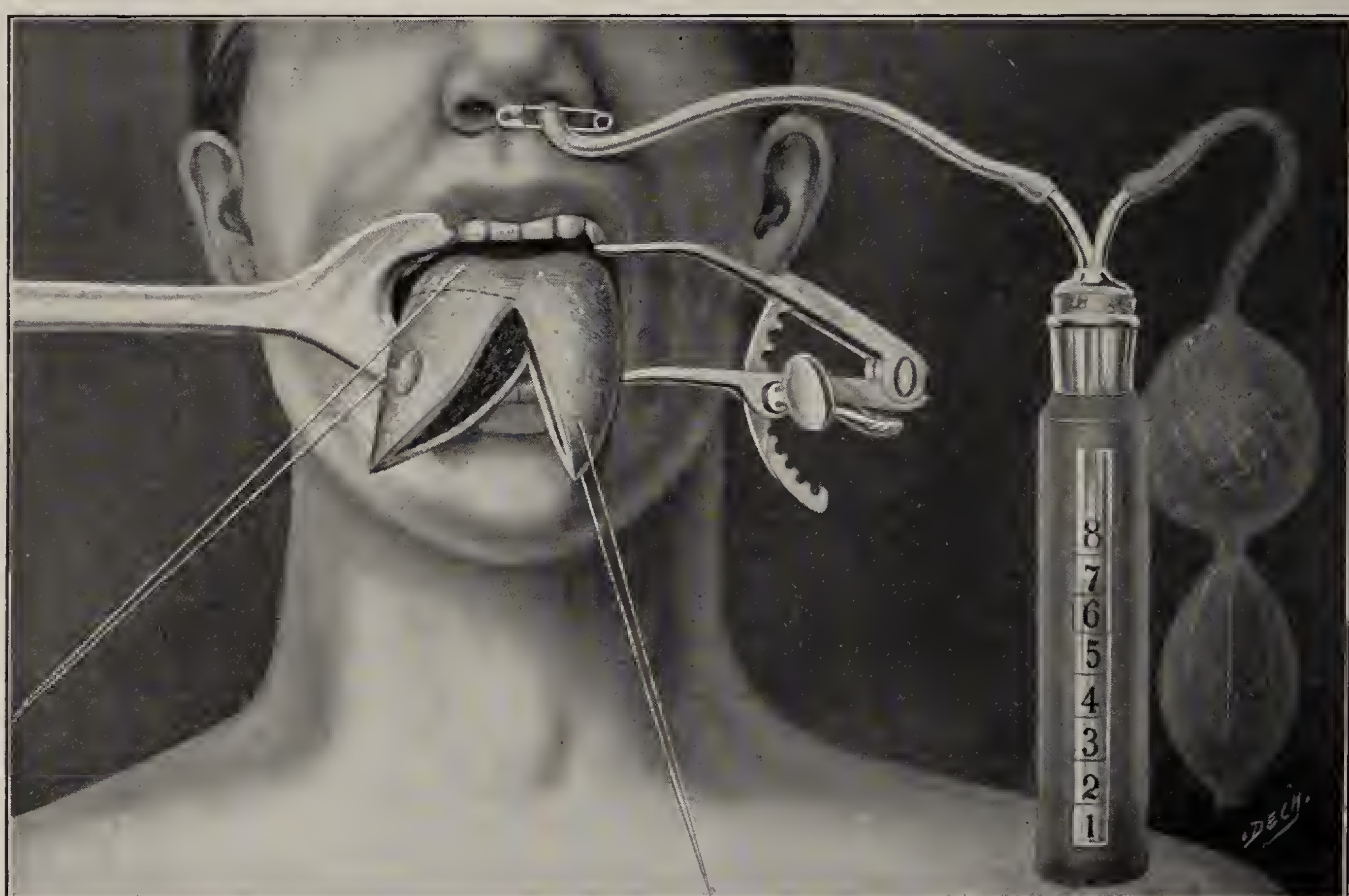


Fig. 323.—Whitehead's Operation for Excision of One-half of the Tongue. Showing Junker's inhaler in use. The tube leading to the nose should be longer than that shown in the illustration.

The patient is placed in bed with the head turned toward the affected side. As soon as he recovers from the anesthetic he is propped up in bed and allowed to sit up in a chair as soon as practicable. The mouth should be frequently irrigated with a boric acid or permanganate solution and sprayed with hydrogen peroxid. To assist in carrying off the secretions Trendelenburg carries a large drainage-tube through the floor of the mouth.

Whitehead's Method for Extirpation of the Entire Tongue.—The tongue is brought well forward and secured by a ligature passed through its tip. The organ is then separated from the floor of the mouth by blunt scissors, and the anterior pillars of the fauces are divided. The lingual arteries are secured. A ligature is passed through the glosso-epiglottidean fold behind the point of transverse section, to secure the stump and draw it forward, if necessary, after the tongue is removed. The extirpation is now completed.

The parts are thoroughly cleansed by swabbing with a 1 : 1000 solution of biniodid of mercury and painted with an iodoform styptic varnish. This is made by substituting for the spirit ordinarily used in the preparation of friar's balsam a mixture of 1 volume of ether and 10 volumes of turpentin, to which iodoform is added to saturation. The patient is fed as freely and as early as possible, the varnish being applied at least once daily. The ligature at the base of the tongue is either fastened to the teeth or kept hanging out of the mouth by the weight of a pair of forceps, and is usually removed at the end of twenty-four hours.

When the floor of the mouth is extensively diseased, the method of **median section of the lower jaw** will be useful. The soft parts are incised vertically and cleared away from the jaw in front and an inch or more on each side. The bone is divided at the symphysis and the two halves forcibly separated. The tongue is now secured, drawn strongly forward, and readily extirpated, together with the diseased structures in the floor of the mouth. The bone is replaced and sutured with silver wire, drainage provided for through the floor of the mouth, and the soft parts united with sutures.

Billroth performed a **temporary resection of the median portion of the lower jaw.**

Fig. 324.—Splitting the Cheek for Extirpation of the Tongue.

When the disease extends from the base of the tongue and involves the surrounding structures, the organ cannot be protruded. In order to obtain ready access and get well beyond the disease, one of the extrabuccal methods must be adopted. The simplest extrabuccal method is that of **splitting the cheek.** The incision is carried through the entire thickness of the cheek from the angle of the mouth back to the masseter (Fig. 324). If the access gained is still insufficient, and particularly if infiltrated glands are present in the neck, the incision should be carried across the angle of the jaw and thence curved so as to pass down the anterior margin of the sternomastoid, and the jaw divided at the level of the last molar (Langenbeck). The anterior portion of the jaw is retracted firmly forward and the posterior portion is retracted outward, as wide a gap as possible being made between the two portions. After the removal of the involved glands, the tongue itself, and the surrounding implicated structures, the divided jaw is wired together.

In some cases of extensive involvement it may be advisable to dissect out the glands, and as much as possible of the branches of the external carotid artery on each side, and then to dissect out the tongue and adjacent diseased structures at a subsequent operation.

Kocher's Method.—The advantages of this method are (1) it gives ready access to the parts; (2) it permits simultaneous removal of all of the tissues in the floor of the mouth and the glands as well; (3) it permits preliminary ligation of the lingual and of the external carotid artery when necessary; (4) the pharynx can be plugged after preliminary tracheotomy, this, together with the efficient drainage which can be obtained, constituting a safeguard against septic bronchitis and pneumonia.

A preliminary tracheotomy is performed, and the chloroform thereafter given through the Trendelenburg cannula (Fig. 311). Or Crile's method of administering chloroform through nasal tubes and tamponing the pharynx may be employed. The incision commences just below the lobe of the ear, extends along the anterior border of the sternomastoid to the middle of the latter; thence to the middle line of the neck and finally upward to the border of the lower jaw (Fig. 325). The flap is dissected up and kept well retracted by being sutured to the cheek. All glands beneath the upper portion of the sternomastoid and under the angle and body of the jaw are removed. The anterior border of the sternomastoid is bared to the sheath of the large vessels, and the greater cornu of the hyoid bone and the anterior belly of the digastric laid bare. The mass of glands is now raised and the posterior belly of the digastric and the stylohyoid exposed in the posterior and lower portion of the wound. The submaxillary salivary gland is dissected up as far as the border of the jaw and removed with the lymphatic glands. The facial vessels are ligated while the submaxillary gland is drawn upward; the lingual artery is ligated as it passes beneath the hyoglossus muscle. The mylohyoid muscle and its mucous membrane covering are cut through close to the bone and the tongue drawn out through the opening. The attachments of the tongue to the hyoid bone are now separated, together with all infiltrated tissues. If the entire tongue is to be removed, the opposite lingual artery is to be ligated through a separate incision (see Ligation of the Lingual Artery, page 558).

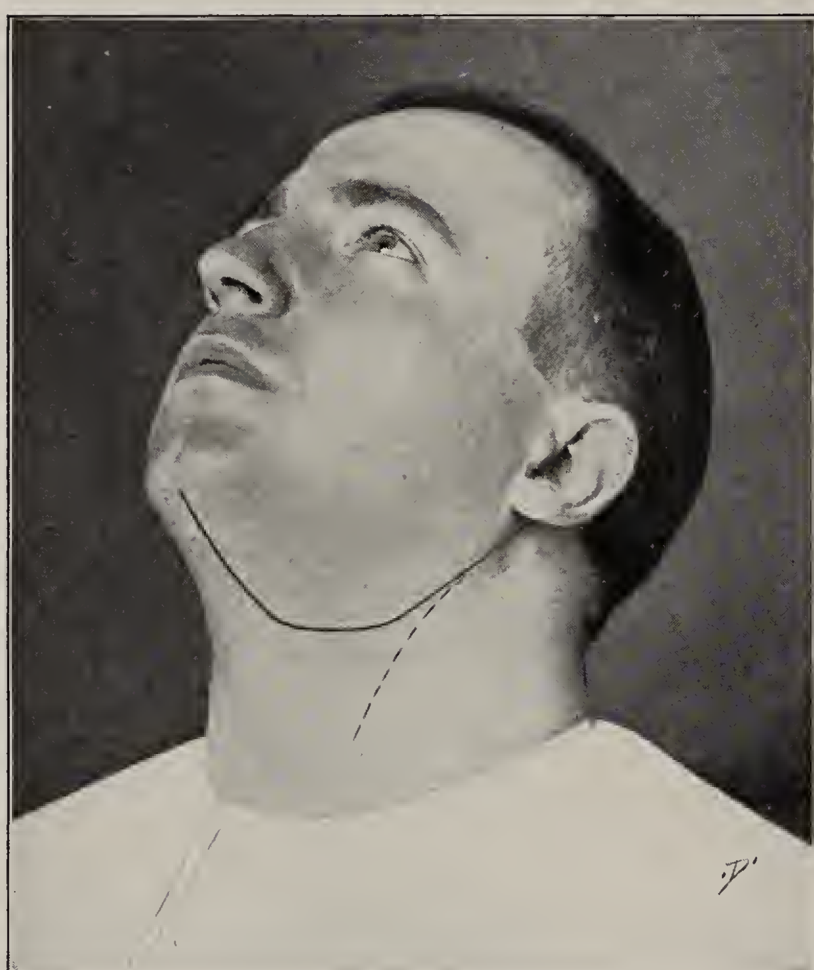


Fig. 325.—Line of Incision for Kocher's Operation for Cancer of the Tongue.

A second incision may be carried in the direction of the dotted line to facilitate the removal of infected glands.

If the carcinomatous infiltration involves the pharyngeal walls, these can be reached through the same opening. The periosteum in front of the masseter and pterygoid muscles is detached from the jaw, the bone sawed through and drawn well forward, in order to gain more room. The bone is afterward wired.

The wound is left open for drainage. The Trendelenburg tube is

replaced by an ordinary tracheal cannula which is worn until the wound is well granulated. The pharynx is packed with zinc oxid gauze and the patient fed with a tube at each change of dressing, at which time also the parts are cleansed with hydrogen peroxid and irrigated with permanganate of potassium solution.

Nonmalignant Tumors of the Tongue.—These occur very infrequently, as compared with malignant growths. **Tumors of embryonic origin** resembling sacrococcygeal and similar tumors are sometimes found in the tongue.

Lipomas.—These are usually single, situated on the border or tip, or on the dorsal aspect, with the overlying mucous membrane smooth. They are of slow growth and produce but slight inconvenience except when they attain sufficient size to be caught between the teeth. When occurring in the depth of the substance of the tongue, they may protrude beneath the latter; the golden yellow color shining through the mucous membrane serves to distinguish it from so-called ranula. **Multiple and diffuse lipomas** have also been observed.

Fibromas.—These are observed most frequently on the dorsum and may occur as multiple growths, with varying distances between the growths. They commence in the substance of the tongue, but finally project from the surface after assuming a polypoid form (**fibrous polypi of the tongue**). They resemble fatty tumors in this region, except that they lack the yellowish hue peculiar to lipomas. They become irksome in the course of time from interference with speaking and eating.

Fibromyomas and **rhabdomyomas** occur as circumscribed growths in the substance of the tongue. The latter are non-encapsulated, and may attain the size of a pigeon's egg. In consistency and color they resemble the normal structure of the tongue.

Cartilaginous and **osseous tumors** occur either as congenital chondromas and osteomas, or develop after birth as mixed tumors containing cartilage, bone, fibrous tissue, and fat.

Amyloid tumors are non-encapsulated amyloid masses occurring at the base of the tongue in patients dying of diseases in which amyloid degeneration occurs. Cartilaginous and bony nodules are sometimes found in the waxy substance.

The **treatment** of the foregoing consists of the enucleation through a single incision of those growths which are deeply situated. Polypoid growths are removed simply by cutting through the pedicle. Multiple and diffuse lipomas occurring in elderly individuals, and giving rise to no special inconvenience, should not be interfered with.

Angiomas.—These occur on the tongue in the same forms as elsewhere, the varieties including (1) arteriovenous aneurism; (2) aneurism by anastomosis or cirsoid aneurism; (3) capillary nevi; (4) venous nevi.

Arteriovenous aneurism may result from a wound and is recognized by its pulsation and thrill.

In **aneurism by anastomosis** the tumor is more or less definitely circumscribed and the vessels possess a distinct wall. The growth may occupy the front half or one of the lateral halves of the tongue (Fig. 326) or appear in the situation of a ranula. The tumor may be emptied by pressure, but it refills when the pressure is relieved. Pulsation is more or less marked. Hemorrhage does not usually occur.

Capillary nevi may be congenital or acquired. When congenital, they

are often multiple and occur on other parts of the body as well as on the tongue. They may be continued into the mouth as a simple port wine stain on the face. In the acquired form they have been observed in pregnant women and in others also. They appear as bright red tumors varying in size from a pin's head to a split pea. Arterial hemorrhage occurs, especially on eating.

Fig. 326.—Cirsoid Aneurism of Tongue of Twenty Years' Standing in a Woman Forty Years of Age.

Venous Nevi (Cavernous Tumors).—Venous angiomas are, as a rule, congenital. They may be single or multiple, and are generally situated on the dorsum of the organ in the anterior half. They project slightly and their dull bluish or livid color shows through the thinned mucous membrane; small varicose vessels and vascular areas appear on the mucous membrane. This variety of angioma seldom attains a large size, is painless, as a rule, and does not usually give rise to great inconvenience. Profuse hemorrhage may occur from accidental injury.

Lymphangiomas may begin with what appears to be a simple nevus; with the steady advance of the lymphangioma marked **macroglossia** may ensue.

Lingual angiomas, like similar vascular tumors elsewhere, occasionally become partly obliterated by fatty degeneration.

The **diagnosis of angiomas of the tongue** is made on the same basis as vascular tumors in general, namely, the color, consistency, diminution in size on pressure, and rapidity of return to their original dimensions when the pressure is relieved. An arteriovenous aneurism may give a history of an injury; the presence of a thrill is characteristic. In cirsoid aneurism large tortuous vessels are present. Capillary nevi of congenital origin are similar to the common "birthmark" seen on the skin. Acquired capillary nevi exhibit a tendency to bleed, particularly in the case of women during pregnancy. Venous cavernous nevi are usually situated on the anterior half of the tongue; small varicose vessels and vascular spots are observed on the mucous membrane covering the nevus.

Fig. 327.—Cirsoid Aneurism of the Tongue.

Showing swelling in the neck when the tongue is retracted into the cavity of the mouth.

Treatment of Angiomas of the Tongue.—In cases showing a tendency

to progressive growth early operation is indicated. Small nevi may be destroyed with the galvanocautery or thermocautery; two or three applications may be needed. The hemorrhage is slight if a dull red heat only is employed. Removal *en masse* by means of an elastic or other ligature is liable to be followed by septic pneumonia. Excision of a wedge-shaped piece, the incision passing beyond the vascular area, is the operation of choice. The vessels can be usually secured in the healthy tissues and oozing arrested by deep suturing. The cut surfaces may be touched with the cautery or the entire excision may be performed with the latter. In large and diffuse cavernous tumors, cirsoid aneurism, and arteriovenous aneurism electrolysis at several sittings may be tried. Preliminary ligation of the linguals should be practised before either electrolysis or excision in this class of cases.

Papillomas are among the most common nonmalignant tumors of the tongue. They are not limited to the papillary area of the organ, but are sometimes found on the under surface. The entire fungiform papillae of the tongue may become involved in a warty enlargement. A peculiar form of sublingual growth, the product of an inflammatory process due to irritation, is known as **Riga's disease.** It occurs on either side of the frenum in young children from contact with the sharp incisor teeth. The treatment is by excision.

Sessile warty growths which form on patches of leukoplakia commence as an apparent thickening of the surface of the latter. Later on they assume a more decidedly warty character, and finally, if left untreated, become indurated about the base, a condition indicating the cancerous nature of the affection in this stage of its development.

In the **diagnosis of papillomas** care should be taken to differentiate the disease from warty syphilitic growths, or condylomas, particularly in children and young adults. A 10 grain to the ounce solution of chromic acid causes a syphilitic growth to disappear rapidly, while a true papillary growth is unaffected by the application. If accompanied by chronic superficial glossitis in a male between thirty and sixty, the differential diagnosis from epitheliomas is not so easy. The presence of ulceration, and of induration about the base, is of importance as showing the presence of malignant disease. If the latter has indubitably supervened, the microscope will aid in the differentiation.

The **treatment of papillomas** consists in their early removal, particularly in persons over thirty. The base should be included in two elliptic incisions extended deeply into the substance of the tongue and the growth removed with some of the adjoining healthy tissue. The gap left is closed by sutures. If ulceration and an indurated base are present, the operation should be as if for epitheliomas, even if the microscopic examination is negative, since the latter may fail to discover the difference in the period of transition from a benign to a malignant growth. Caustics should never be used on these growths. Destruction by means of the galvanocautery is inferior to excision.

Hypertrophy of the Blandin-Nuhn gland beneath the tip of the tongue has been occasionally observed.

Ligation in Continuity of the Lingual Artery.—A cushion or block is placed beneath the patient's shoulders and the head turned slightly toward the opposite side. The incision is commenced slightly to the outer side of the symphysis menti and about $\frac{1}{4}$ of an inch above the body of the hyoid bone. With its convexity downward it is carried for about two inches along

the border of the jaw, reaching to a point just in front of where the facial artery crosses the latter. Its center is just above the greater cornu of the hyoid bone. After separation of the skin, platysma, and superficial fascia, the submaxillary gland comes into view. This is to be separated from its surrounding connective-tissue attachments and retracted upward, the lower edge of the incision being retracted downward at the same time (Fig. 328). The two bellies of the digastric muscle now come into view. The hypoglossal nerve and ranine vein are exposed by depressing the digastric at the point where its two bellies meet, with a blunt tenaculum. By retracting the nerve

Fig. 328.—Ligation of Lingual Artery, showing Hueter's Triangle.

and vein in an upward direction the **trigonum linguale** (H u e t e r) is formed. The artery lies at the lower portion of this triangle, beneath the thin hyoglossus, which muscle is divided in a horizontal direction. At this point the vessel changes its direction from the horizontal and assumes a vertical course to enter the tongue; it is usually accompanied by a small vein.

The operation is performed most frequently for disease of the tongue, preliminarily in complete extirpation for carcinoma, or to restrict the circulation and thus limit the nutrition of diseased portions of the organs, as, for instance, in hemihypertrophy.

THE SOFT AND HARD PALATE

THE VELUM

Wounds of the soft palate are not usually followed by septic inflammatory processes. Cicatrization of wounds of the velum sometimes leads to **interference with speech,** and whenever possible primary union should be secured by suturing. **Foreign bodies** are usually removed without difficulty.

Primary inflammation of the soft palate is not common, but it usually

takes more or less part in that arising in the adjacent parts. **Phlegmonous inflammation** in the peritonsillar connective tissue (**quinsy**), as well as **diphtheria** of the tonsils and pharynx, may extend to the soft palate. **Syphilitic ulceration** may occur, and, by cicatrization, necessitate a subsequent plastic operation. The **uvula** may become the seat of edematous swelling from slight causes and be considerably lengthened.

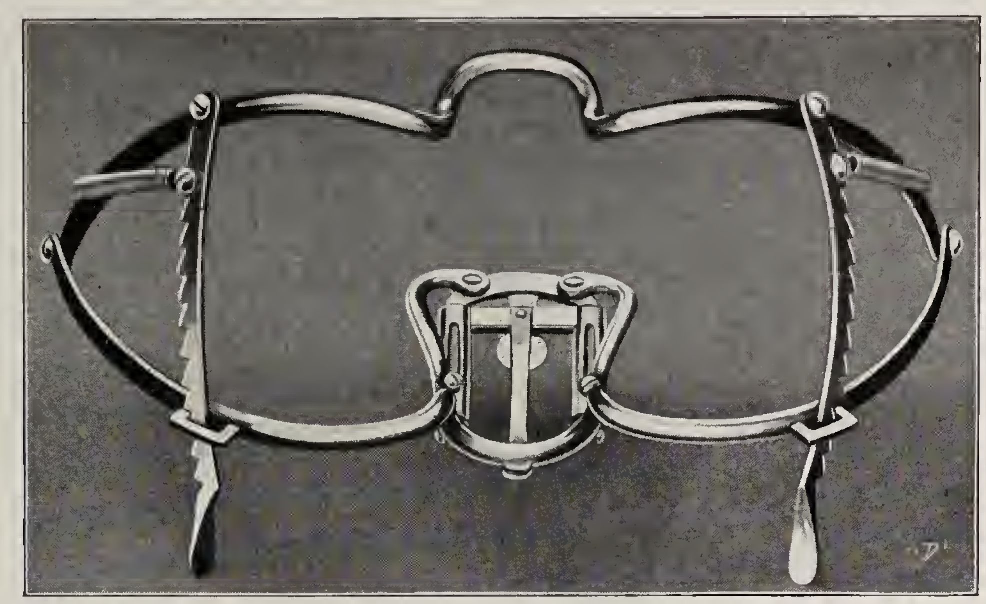


Fig. 329.—Whitehead's Gag.

Fissures of the Soft Palate.—**Congenital fissure** of the soft palate constitutes one of the forms of **cleft palate.** It occurs almost exclusively in the median line. The uvula is usually involved in the fissure. The margins of the fissure, when complete, terminate at an acute angle at the posterior edge of the hard palate; the latter may be invaded for a short distance. Incomplete fissure extends only a part of the way; the uvula alone may be involved (bifid uvula).

Acquired Cleft of the Soft Palate.—Unhealed wounds of the soft palate may result in a cleft, this varying in form and extent. This condition is also due to constitutional syphilis, and presents, under these circumstances, the rather constant and characteristic form of an oval or oblong shape due to the fusion of several openings resulting from gummatous infiltration, with varying degrees of destruction. The ulceration

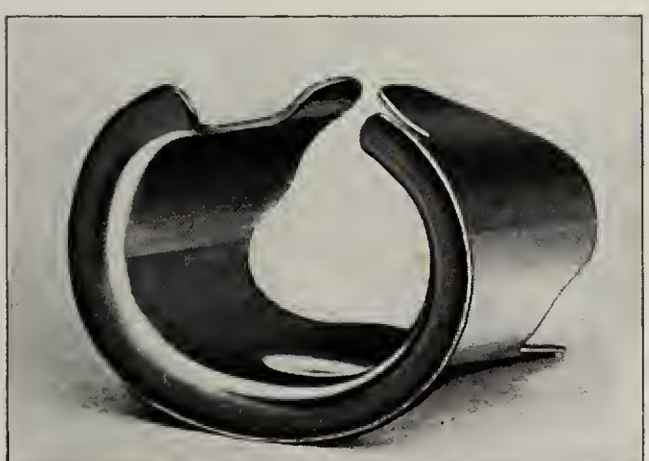


Fig. 330.—Brophy's Mouth Speculum.

Fig. 331.—Brophy's Mouth Speculum Applied. Patient in the dependent head position of Rose.

frequently extends from the posterior surface of the velum to the adjacent pharyngeal walls; fusion occurs and the margins of the remains of the soft palate are dragged to each side, greatly enlarging the fissure. Disturbances of speech and deglutition are marked.

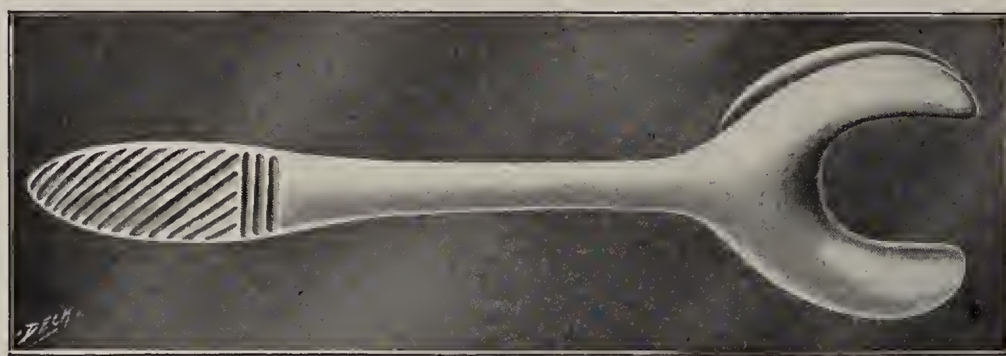


Fig. 332.—Cheek Retractor.

The **treatment** of congenital cleft of the soft palate is by staphylorrhaphy. Acquired clefts of traumatic origin may be similarly treated where there is not great loss of substance. Those due to syphilitic infection are best treated by an obturator or artificial velum (Kingsley, Suersen).

Operation of Staphylorrhaphy.—The operation is divided into (1) paring the margins; (2) dividing the muscles to relieve tension; (3) introducing the sutures.

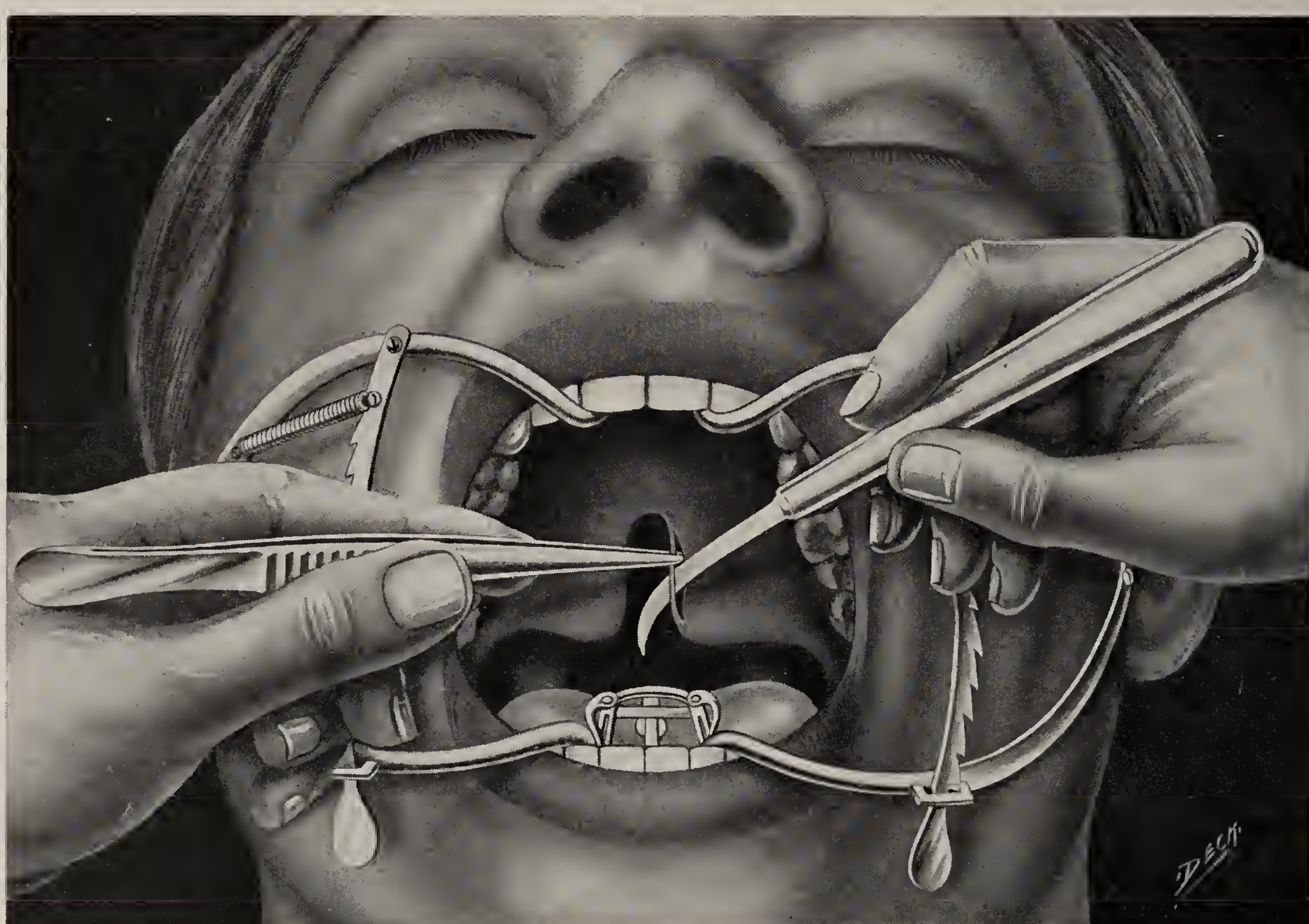


Fig. 333.—Staphylorrhaphy. Paring the Edges.

Paring the Margins.—A suitable gag or mouth speculum is introduced (Figs. 329 and 330). A cheek retractor is of service (Fig. 332). The dependent head position of Rose is the best (Fig. 331). One edge of the fissure is grasped by a tenaculum or mouse-toothed forceps and a thin and narrow-

bladed bistoury is passed through just in front of the angle and at a little distance from the margin. By gently sawing movements the incision thus

Fig. 334.—Staphylorrhaphy Scissors for Dividing the Levatores Palati.

commenced is carried parallel to the margin until the tip of the uvula is reached (Fig. 333). This is repeated on the other side. The two incisions are then united at the bottom of the angle by a curved cut made by a sweeping movement of the knife, the paring being removed in one piece.

Fig. 335.—Needle Armed with Carrier.

Dividing the Muscles.—If this is done before introduction of the sutures, a sickel-shaped knife (Langenbeck's) is passed through the cleft, its point introduced over the hamular process, which can be felt by the point of the finger in close relation to the last upper molar, and the section made while the corresponding portion of the velum is made tense. Or, the double curved scissors may be employed for this purpose (Fig. 334). These incisions divide the levatores palati. If tension still exists, the palatopharyngei may be divided simply by cutting across the posterior pillars with blunt scissors.

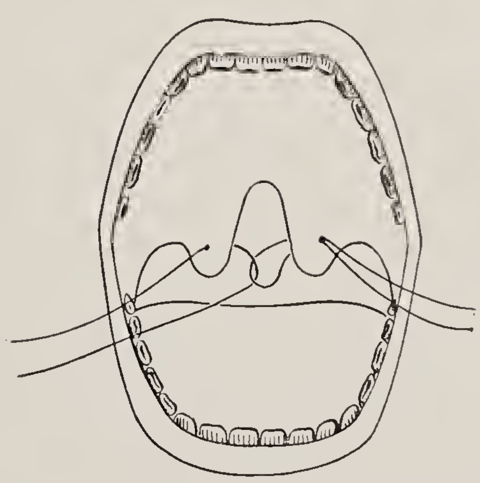


Fig. 336.—Passing the Sutures in Staphylorrhaphy (Diagrammatic).

Introducing the Sutures.—A small half-circle needle grasped by a needle holder serves best, when it can be employed. A needle with the eye at the point may be passed armed with a "carrier," *i. e.*, a double thread (Fig. 335), the "bight" or loop of which is left in the gap. A single thread is then introduced from the other side, its free end passed through the carrier and the latter withdrawn, carrying with it the single thread which is to remain as a suture (Fig. 336). An ordinary needle, if small and well curved, may be employed when armed with a carrier. A good quality of silk is the best suture material.

THE HARD PALATE

Slight injuries of the mucous membrane covering the hard palate arising from **foreign bodies** in the food are unimportant. Those which involve the

entire thickness, as, for instance, when they are caused by the fall of a child with a pencil or toy in its mouth, or **perforation** occurs by a pistol ball, are of greater importance. When the latter involves a suicidal attempt, there is accompanying extensive contusion of the surrounding soft parts.

Suppuration of the antrum of Highmore may follow the last named injury. There may be some limited **necrosis,** but the sequestra easily separate and the opening finally closes. Extensive destruction of bone may lead to a permanent communication between the cavity of the mouth and the nasal cavity in case of median situation of the opening, and between the cavity of the mouth and the antrum of Highmore in case of lateral situation.

Suppurative periostitis occurs as an extension of a similar condition from the alveolar processes in phosphorus poisoning. When sequestra are separated they should be removed from the direction of the gums, but not by an incision in the median line, lest a permanent opening be left in the roof of the mouth communicating with the nasal fossa. The exfoliated portions are usually replaced by new bone formation. **Syphilis of the palate** appears almost exclusively in the shape of gummas, the nodule of which is strictly limited to the median line or **raphe** of the palate where the two palatal processes of the superior maxillary bone join the septum. A bony ridge marks the site of the syphilitic infiltration if the diseased condition is arrested by appropriate treatment. Otherwise the entire thickness of the bone becomes affected, more or less of the bony vault is destroyed, and with the final cicatrization small or large openings are left. These may be distinguished from those due to injury by the fact that they are situated in the median line and are oblong in shape, while those from injury vary in situation and are usually round.

Congenital Cleft of the Hard Palate.—This may be partial or complete. It is always associated with cleft of the soft palate. The cleft may pass to one side of the vomer; more commonly, however, it passes directly in the median line, leaving the palatal edge of the vomer free. It is frequently, though not invariably, associated with harelip. The latter may be single or double. In complete cleft of the hard palate the fissure is V-shaped, with the opening of the angle posteriorly situated, and with the anterior portion and the alveolar processes intact. In complete cleft the fissure passes to the alveolar processes in front and in some instances involves it. The latter condition always obtains when double harelip is present, on account of the forward displacement of the premaxillary bone.

The **functional disturbances** in the newborn resulting from cleft palate relate principally to interference with suckling. As a rule, the infant will require to be artificially fed. A feeding bottle with a large nipple to close the gap, or a specially constructed nipple with a rubber shield, may be used. Malnutrition is not uncommonly present in spite of these appliances.

Defects in speech in older children are next in importance. As the child learns to talk it will be found that these are present, generally speaking, in proportion to the extent of the cleft. In cases uncomplicated by harelip labial sounds are usually enunciated without difficulty; those requiring pressure of the tongue against the hard palate and of the velum against the posterior pharyngeal wall are lost. Even under the most favorable conditions of a short cleft the impairment of speech, consisting of a broad nasal sound, is noticeable.

Unfortunately, in the majority of cases the habits of speech first formed cling to the patient, even after the most successful operative closure, or the application of an obturator and artificial soft palate. The continued impairment is due in part to absence of development of the levator palati and palatopharyngeal muscles, and in part to early acquired habits of speech. These are more difficult to overcome after operative closure than in case of application of an obturator and artificial soft palate, for the reason that division of the muscles to relieve tension on the approximated edges of the cleft in the soft palate is usually necessary, this involving permanent impairment of these to a greater or lesser extent. When an obturator and artificial velum are properly fitted, the muscular apparatus of the soft palate is brought into use. With careful training by means of selected vocal exercises the muscles develop, and at the same time faulty habits of speech are corrected.

The lodgment of particles of food in the nasal cavities, leading to catarrhal inflammation of these, constitutes a further indication for operative correction of the defect, or the application of a proper prosthetic apparatus.

Treatment.—Opinions differ as to the age at which operative measures should be instituted for cleft palate. In view of the fact that faulty habits of speech, once acquired, are very difficult to overcome, Wolff, of Berlin, advised operative interference in early infancy. His method was to loosen by means of the chisel the remains of the hard palate adjoining the alveolar processes, and to force these toward the median line until the previously freshened margins of the cleft palate came into apposition (**osteoplastic closure**). The gaps left by this median displacement of the lateral portions of the hard palate were left to heal by granulation. The cleft in the soft palate was closed by the usual staphylorrhaphy (see page 560). By operating in this manner before the child learned to talk, it was thought that one of the causes of permanently defective speech, namely, habit, would be overcome. In order to avoid the necessity for division of the muscles, however, operation in the earliest period of the infant's life is demanded. It is surprising to what an extent the muscles attached to the soft palate make tension upon and separate the edges of the cleft in this region during the act of crying, even in an infant only a few weeks old.

If this earlier period of life is chosen for operation, however, the latter must necessarily involve a higher mortality, since very young infants succumb more easily to the combined effects of shock and loss of blood than those farther advanced. This consideration is somewhat compensated for by the fact that the operation may be performed on the former without the administration of an anesthetic.

The method of osteoplastic closure of the cleft by forcing together both the lateral portions of the hard palate and the alveolar processes (Brophy), the gaps left by section of the former being thus avoided, succeeded the method of Wolff. This can be done with comparative ease in very young infants. The resulting narrowing of the face disappears in time. The edges of the cleft are first carefully freshened in their entire extent. The superior maxillas are perforated on each side just above the alveolar processes at the gingivobuccal fold and two stay wires of silver passed above the plane of the cleft. The ends of these are passed through carefully fitted lead plates placed between the cheek and the gum. The maxillas are now forced together, the special

compression forceps of Brophy or other mechanical means being employed if necessary. If the bone does not yield readily, it may be weakened just above the level of the stay sutures by one or more short incisions with a stout scalpel. When approximation is secured the raw edges of the cleft are united by a row of fine silk sutures.

More or less blood may be swallowed by the patient during the operation, and the fever following the digestive disturbances and absorption may interfere with the healing process. Every care should be taken, therefore, to avoid the swallowing of blood by keeping the parts carefully sponged and the pharynx clear. The administration of an emetic, followed by a simple purge, is an additional safeguard against failure from this cause. Occasional cleansing of the mouth with a boric acid solution, particularly after food has been taken, should be practised.

The operation of **uranoplasty,** as applied to older children and adults, is performed as follows: The mouth is carefully cleansed, ether administered, and the patient placed in the dependent head position of Rose (Fig. 331). After the patient is fully anesthetized the administration of the ether is carried on through the Junker inhaler (Fig. 323). A suture is passed transversely through the dorsum of the tongue *behind* the frenum and given in charge of an assistant. The largest sized combined oral speculum and tongue depressor (Fig. 330) that the oral opening will accommodate is introduced. Or the rack-and-pinion mouth-gag may be employed (Fig. 337). The edges of the cleft are carefully freshened, as in staphylorrhaphy (Fig. 333). The mucoperiosteal coverings of the hard palate are now thoroughly separated from the bone in all directions by means of the raspatory (Fig. 338). In carrying out this step of the operation care should be exercised not to contuse the freshened edges of the soft parts of the cleft. The elevator should be kept close to the bone and the process continued until the entire hard palate is denuded.

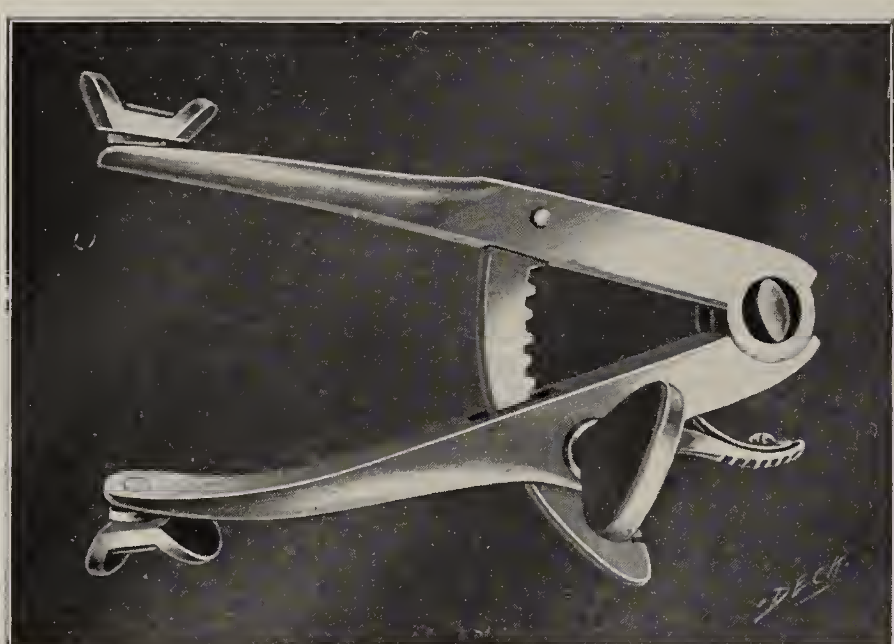


Fig. 337.—Rack-and-pinion Mouth-gag.

A traction suture is now passed through the velum on each side and each half drawn strongly forward and toward the opposite side, while the finger palpates the site of the levator palati and palatopharyngeal muscles of the corresponding side to determine the amount of tension present. Usually these will require division (see Staphylorrhaphy, page 560). The fact that these have been thoroughly divided will be determined by the palpating finger.

The ability to approximate the edges of the mucoperiosteal flaps is now tested. In cases in which a high arch or vault exists the edges will fall together easily. In a low or flat vault the edges will fail to approximate, and

a relaxing incision parallel to the alveolar margin on each side must be made. These incisions must not be made longer than is necessary to effect approximation, lest the blood-supply be interfered with and sloughing of the flaps ensue.

In the **application of the sutures** provision must be made for removing all possible strain from the line of union. The **relaxation sutures** intended to accomplish this are of silver wire, are passed through the flaps about half-way between the freshened margin and the edge of the relaxation incision of each side, and are secured by being passed through a narrow and thin lead plate and clamped with perforated shot. When the edges have been accurately adjusted by means of the relaxation sutures they are united by a row of fine silk sutures. The lateral gaps are packed with sterile gauze.

In order to prevent the child from reaching the line of sutures and separating them with the tip of the tongue the latter may be secured by a suture to

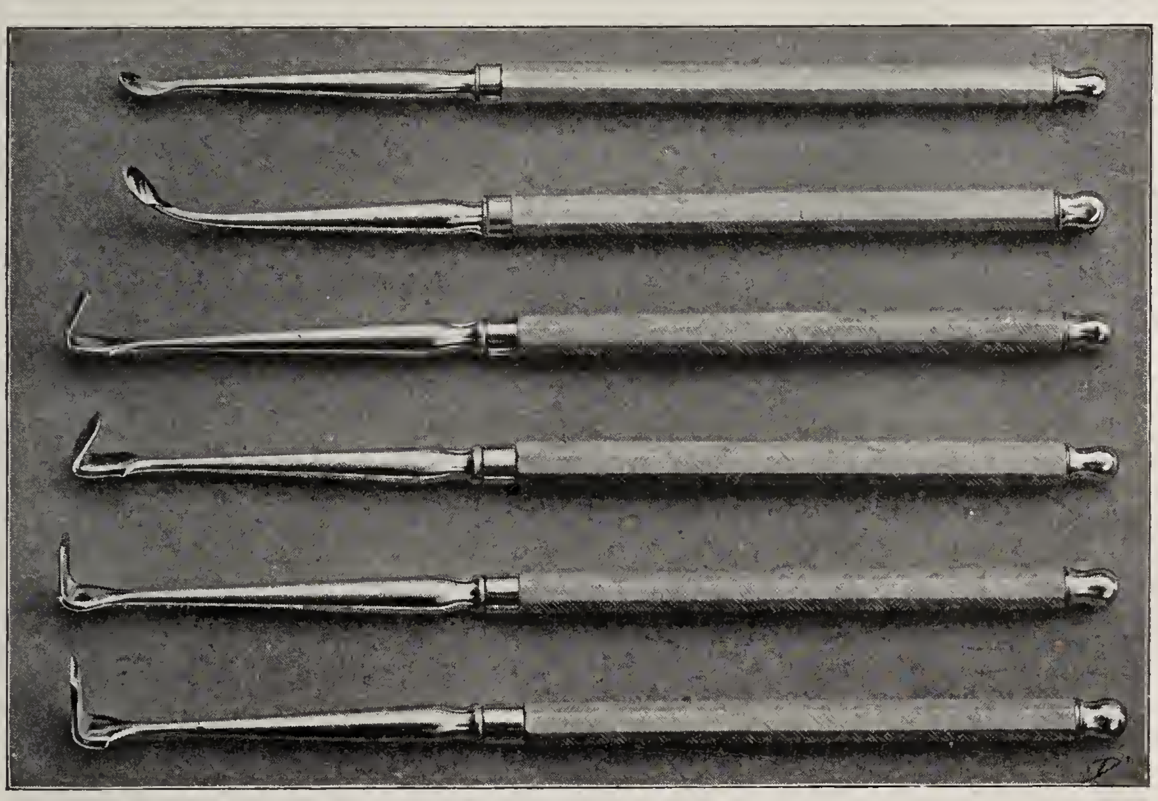


Fig. 338.—Raspatories for Uranoplasty.

the lower gingivolabial fold for the first few days, in cases in which the lower front teeth are absent. Careful antiseptic cleansing should be carried out in the after-treatment. The palatal sutures may be removed from the eighth to the tenth day.

The Non-operative Treatment of Cleft Palate.—The application of a prosthetic apparatus involves considerable expense and is beyond the reach of poor patients. It cannot be advantageously applied until the permanent teeth have erupted. Constant care is necessary to cleanse the apparatus properly and prevent damage to the teeth to which it is attached. The latter should be regularly inspected by a competent dentist. To offset these disadvantages, it may be said that the functional results are far superior to those obtained by any operative procedure performed after the patient has learned to talk, provided pains are taken to train the vocal organs properly after its application.

THE FAUCES, PHARYNX, AND NASOPHARYNX

THE TONSILS

The tonsils are vestigial structures, endowed with a low power of vital resistance and with numerous recesses which invite the presence of agents of infection. For these reasons they are very liable to become the seat of inflammatory processes.

Acute Tonsillitis.—This occurs in connection with acute catarrhal pharyngitis. The attack may resemble erysipelas of the skin; in fact, facial erysipelas may be accompanied by a hyperacute inflammation of the mucous membrane of the oral, nasal, and pharyngeal cavities.

Follicular Tonsillitis.—This may follow an attack of acute catarrhal tonsillitis. It usually pursues a chronic course, with occasional acute exacerbations. The tonsils swell considerably and project from between the faucial pillars. The contents of the crypts accumulate and are either removed by coughing or become desiccated and form concretions (tonsillar calculi). Decomposition of the accumulated secretions sometimes gives rise to a foul breath.

Hypertrophic tonsillitis results from either acute catarrhal tonsillitis or follicular tonsillitis. Repeated attacks of the former, a long continuance of the latter, or a mixture or alternation of the two, induce connective-tissue hyperplasia and enlargement of the tonsils to the extent of a tumor as large as the end of the thumb or larger.

Phlegmonous tonsillitis (peritonsillitis) is a phlegmonous inflammation of the peritonsillar connective tissue. The connective tissue of the tonsil proper is composed of short and rigid fibers and is but little prone to phlegmonous inflammation. The infectious agents of a catarrhal or follicular tonsillitis may pass to the connective tissue between the tonsil and the faucial pillars and set up a phlegmonous suppurative inflammation.

Diphtheritic Tonsillitis.—This form is characterized by the formation of a pseudomembrane on the surface. The false membrane consists of layers of micrococci, fibrinous filaments, pus corpuscles, and epithelium. The pellicles, the coalescence of which makes up the bulk of the false membrane, develop first in the depths of the tonsillar crypts as the result of the presence of the special bacillus of the disease (Klebs-Löffler). The presence of this bacillus may be demonstrated by bacteriologic examination for diagnostic purposes (see page 29).

Ulcerative conditions of the tonsils are observed. These are (1) **syphilitic**; (2) **carcinomatous**; (3) **tuberculous**; (4) **lupous.** Those due to syphilis extend to the velum and pharyngeal mucous membrane; those of a carcinomatous nature are to be differentiated by the microscopic section; tuberculous ulceration is usually accompanied by general tuberculosis, in addition to which the bacillus tuberculosis may be found by microscopic examination.

Symptoms.—Swallowing is greatly embarrassed in phlegmonous tonsillitis, rather less so in the acute catarrhal form, still less in the follicular and least of all in the hypertrophic form. **Respiration** may be interfered with, notably

in the phlegmonous variety. The inflammatory process may extend to the muscular attachments of the inferior maxilla and produce **inflammatory lock-jaw.**

Inspection, in the acute catarrhal form, shows the tonsil to be evenly reddened and slightly enlarged. In the follicular variety yellowish-white spots are seen in the crypts of the swollen organ; slight reddening is present. In hypertrophic tonsillitis the tonsils project like tumors from between the pillars of the fauces, the latter, however, remaining distinct. The tonsils may be so large as to come in contact with each other by their inner surfaces. In phlegmonous tonsillitis also the projection is considerable, but the organ, instead of becoming prominent between the pillars of the fauces, as in the hypertrophic form, carries the palatoglossal pillar along with it toward the uvula. In the latter form the mucous membrane is thickened, intensely red, and covered with glairy mucus. In diphtheritic tonsillitis the false membrane first appears as a grayish veil covering the tonsils near the lower infected crypts; later on, this assumes a characteristic white appearance.

General febrile disturbance occurs in acute catarrhal tonsillitis. This, and in addition enlargement of the submaxillary lymphatic glands, is also present in both phlegmonous and diphtheritic tonsillitis.

Disturbances of function are present to a greater or lesser degree in hypertrophic tonsillitis. There is a **nasal sound** to the speech from rigidity of the velum and separation of the nasal cavity from the pharyngeal cavity. **Impairment of hearing** may result from occlusion of the pharyngeal orifice of the Eustachian tube either by the swollen tonsil or by the accessory inflammation of the pharyngeal mucous membrane. **Mouth-breathing** may become habitual; snoring while asleep occurs from the vibrations in the tense velum.

Prognosis.—This is always grave in diphtheritic tonsillitis, either by extension to the pharynx, larynx, and nasal cavities, or by general infection. Phlegmonous tonsillitis may cause death by extending along the planes of connective tissue and giving rise to **suppurative pleuritis,** or **edema of the glottis;** finally, **suppurative erosion** of the carotid artery and fatal hemorrhage may occur. Usually, however, the focus of suppuration points, and if not incised finally breaks through the thinned mucous membrane, and rapid recovery ensues. Recurrences are liable to take place.

Treatment.—Usually only the phlegmonous and hypertrophic forms come under the surgeon's care. The first demands early incision, this being repeated from time to time until either the suppurating focus is reached or subsidence of the inflammation follows the antiphlogistic effects of the local depletion; the relief of tension and diminution of pressure by division of the peritonsillar structures is also of service, even though no pus escapes. Deep suppuration will sometimes find its way to the bottom of an incision and discharge. A narrow-bladed bistoury is used, and a puncture is made which should be enlarged should pus flow alongside of the knife. Incisions should be made in a vertical direction and care be taken that they are not too far outward, in order to avoid wounding the internal carotid artery.

Tonsillotomy is performed for hypertrophic tonsillitis. The simplest method of performing this operation is to grasp the tonsil with a tenaculum forceps held in the corresponding hand of the operator, draw it toward the median line, and amputate it by a quick stroke of the probe-pointed bistoury

from above downward. Should the surgeon not be ambidextrous he may remove the left tonsil first, grasping it by the tenaculum forceps held in his left hand. He then stands behind the patient, the head is bent backward, and with the tenaculum forceps in his left hand, he uses his right for the cutting. In the latter case he makes the incision from below upward. Care should be taken to make the incision as close as possible to the palatoglossal fold and not to drag the tonsil too far from its bed between the pillars of the fauces, else dangerous hemorrhage may occur from injury to the tonsillar branch of the facial artery or to the large branch of the ascending pharyngeal from the external carotid which takes the place of the tonsillar branch of the facial when the latter is absent. The external carotid artery can scarcely be injured in this operation; it lies at least three-fourths of an inch from the base of the tonsil.

Special instruments (tonsillotomes) have been devised for the operation. Overestimation of the difficulties of the amputation and fear of injury to the carotid artery led to their introduction. While this fear is groundless, still the removal may be facilitated by the use of the instruments particularly in the case of children, and where a general anesthetic is not given. The best of these is that shown in Fig. 339. The ring-shaped extremity is slipped over the organ and adjusted with the index-finger of the left hand, the middle and ring fingers depressing the tongue at the same time. By a single movement the tonsil is

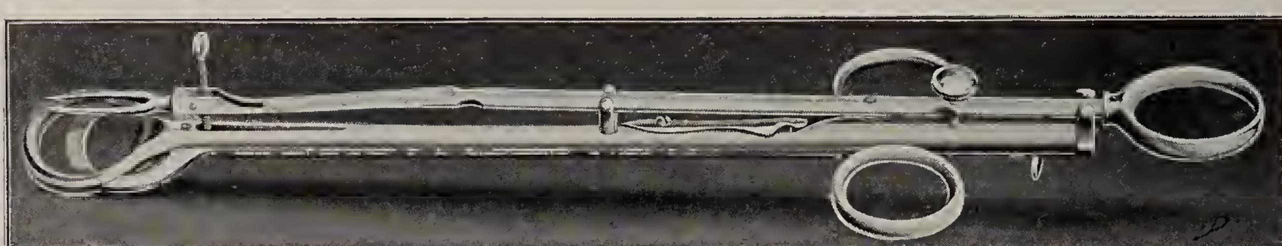


Fig. 339.—Tonsillotome.

seized by the fork of the instrument, elevated and made tense, and amputated by the heretofore concealed blade. Penciling the mucous membrane of the pharynx and tonsils with a 10 or 20 per cent solution of **cocain hydrochlorate** will usually produce a sufficient anesthetic effect. Or **general anesthesia** may be established by means of ether, in which case the upright position (French's) or the dependent head position of Rose may be employed. **Hemorrhage** is generally arrested by gargles of ice-water; this failing, pledgets of cotton wet with spirits of turpentin should be held firmly applied to the bleeding surface. The tonsillar artery proper passes to the tonsil along the front of the levator palati muscle, and as the latter forms a portion of the posterior surface of the soft palate, pressure from behind forward against this structure is indicated.

Latent tuberculosis of the tonsil, manifesting its presence by hypertrophy of one or more of the lymphoid organs in this region, has been observed (Dieulafoy). The bacilli may remain latent for a long time, recovery finally taking place, an indurated fibrous condition of the tonsil remaining. Or the bacillus may find its way into the lymphatic vessels, giving rise to enlarged submaxillary and cervical lymphatic glands. Pulmonary tuberculosis may finally result.

Malignant Tumors.—Malignant disease of the tonsil when primary,

usually occurs as **sarcoma**; this has been observed in patients under twenty. A rapidly growing tumor involves the tonsil and may be readily mistaken in the beginning for simple hypertrophy. Attempts to remove it by ordinary methods, however, will reveal its true nature, and be followed by a sharp hemorrhage from the enlarged tonsillar artery. **Epithelial carcinoma** is usually an extension of the disease either from the soft palate or the tongue, usually the former. It may begin on the pharyngeal surface, extend to the oral surface, to the pillars of the fauces, and to the tonsil, breaking down rapidly into ulceration. The cervical glands become involved early. I have observed it to be a primary disease in one case.

External Pharyngectomy.—This operation is indicated in malignant tumors of the tonsil and faucial pillars or of the pharyngeal wall. The patient is prepared beforehand by thoroughly cleansing the buccal and pharyngeal cavities.

The patient's head is placed on a block, well extended, and turned toward the opposite side. An incision is made from the lobe of the ear along the anterior edge of the sternomastoid muscle to a point three-fourths of an inch below the level of the hyoid bone. A second incision commences half-way between the angle of the jaw and the point of the chin and is carried downward and backward to meet the lower angle of the first incision. The triangular-shaped flap thus marked out is dissected up and includes the tissues down to the sheath of the muscles. Upon retracting the flap, the angle of the jaw, portions of the parotid and submaxillary glands, the stylohyoid muscle, the posterior belly and a portion of the anterior belly of the digastric, together with the omohyoid muscle, are brought into view. A portion of the hyoglossus is visible just below the angle of the jaw. To increase the working space the hyoid attachment of the stylohyoid, as well as the posterior belly of the digastric, may be severed. Further room may be obtained by excision of the submaxillary gland. Finally, under certain circumstances section of the inferior maxilla may be necessary in order to gain access to the parts involved in the disease (Billroth, Cheever), in which case a preliminary impression of the teeth should be taken, and an interdental splint made so that these may be preserved in their proper articulation while the bone is uniting.

The hyoglossal nerve is avoided, the sternomastoid, the stylohyoid and the posterior belly of the digastric, as well as the important vessels and nerves of this region, are bluntly retracted well downward and backward, the mylohyoid being drawn anteriorly. The forefinger and middle fingers of the left hand are passed into the mouth, a gag having been previously introduced, and the parts crowded downward and outward. The pharynx is now opened and the diseased parts extirpated. The thermocautery applied both from the cavity of the mouth and from the external wound may be used at this stage in cases in which there is extensive disease of the faucial pillars and velum as well.

The above procedure furnishes a means of gaining ready access to the parts without sacrificing any important vessels or nerves of this region. The employment of the thermocautery facilitates the final extirpation of the growth, without entrance of blood into the pharynx or larynx, and furnishes protection against cancerous infection of the wound as well.

If section of the jaw has been made, the bone is to be wired and the inter-dental splint finally applied. Under these circumstances a drainage-tube is to be passed into the pharynx from the upper and posterior angle of the wound when the latter is sutured, and the patient fed through this.

During the first four days the after-treatment consists in flushing the parts every two hours with a 2 per cent solution of permanganate of potassium

FIG. 340.—EXTERNAL PHARYNGECTOMY.
1, Hyoglossus muscle; 2, retracted posterior belly of the digastric muscle; 3, stylohyoid muscle divided at its lower attachment at (4); 5, mylohyoid muscle retracted anteriorly; 6, body of mandible.

through a catheter passed through the corresponding naris. This is followed by a solution of hydrogen peroxid applied by the same route. The diet should be limited to sterilized milk. A decided and persistent rise of temperature will require the application of a 5 or 10 per cent solution of chlorid of zinc to the parts once or twice a day. Septic pneumonia is to be feared, as in all extensive operations about the mouth and upper respiratory passages.

FOREIGN BODIES IN THE FAUCES AND PHARYNX

Predisposing Causes.—These may be classified according to the regions in which the conditions exist as follows (Poulet): (1) **the mouth and pharynx**: loss of teeth, facial paralysis, neoplasms, and nervous spasm; (2) **affections in the vicinity**: inflammatory swellings in the neck and resulting changes in the course of the alimentary canal; (3) **affections of the walls**: constrictions and paralytic dysphagia; (4) **predisposing physi-**

ologic causes: these include the natural irregularities of the pharynx which tend to the arrest of difficult substances there. The particular location of the foreign body is frequently determined by the anatomic structure of the parts.

Objects Taken with the Food.—The most common of these are small fish-bones. They are most frequently lodged in the lingual tonsil, where they are sometimes difficult of detection. The **symptoms** are pricking sensations and sometimes pain, which the patient finds difficulty in locating. The patient may insist that the fish-bone is lodged in the vault of the pharynx, when inspection reveals it projecting from the surface of the lingual tonsil, the bone being forced upward by the tongue against the mucous membrane of the nasopharynx with each act of deglutition. The fish-bones may also be lodged in the faucial tonsil, the posterior pharyngeal wall, the pyriform sinuses, or the entrance to the esophagus. If possible, the search should be conducted by the aid of direct or reflected sunlight. Their extraction is usually easily accomplished with properly curved forceps.

Sharp and Angular Objects.—These consist of pins, needles, etc., placed in the mouth, whence they make their way into the fauces or pharynx. Small sharp bodies give rise to pain on attempts at swallowing, coughing, retching, etc. They may be embedded in the tissues and either become encapsulated or give rise to inflammation and suppuration. Or, if sharp, they may migrate and appear beneath the skin of the neck without producing suppuration. Excessive hemorrhage may necessitate ligation of the common carotid artery. These objects may make their way into the Eustachian tube, finally emerging through the external auditory canal. The removal of this class of foreign bodies is usually easy, though in isolated cases it has been necessary to perform external pharyngotomy.

Smooth Round Bodies.—These are rarely arrested in the fauces or pharynx, but pass at once into the esophagus and lodge at the prominence of the cricoid cartilage. Failing to enter the esophagus or lodge at the orifice, they are found in one of the lateral pharyngeal sulci (pyriform sinuses). The symptoms are difficulty in swallowing, cough, and certain reflex convulsive movements of the fauces. If the larynx is involved there may be loss of voice. Impaction of this class of foreign bodies is rare. The foreign body is to be located by inspection by means of direct and reflected light. Digital examination may aid in the diagnosis and is frequently instrumental in dislodging the object directly or by the reflex vomiting which it excites.

Large Objects Irregular in Shape.—False teeth fixed on a plate which have dropped into the pharynx during sleep constitute the type of this class. This accident may also happen during the administration of an anesthetic, as the result of a fall, or while drinking from a large vessel. Large and irregular pieces of bone taken with the food are rather common. They lodge either in the orifice of the esophagus or in one of the lateral pharyngeal sulci. In cases of large irregular objects, death may result from suffocation on account of the difficulty of removal. A foreign body lodged in the orifice of the esophagus may give rise to symptoms demanding tracheotomy.

Finally, foreign bodies in the fauces and pharynx may be the unsuspected cause of pain on swallowing, progressive emaciation, attacks of hemorrhage following ulceration, and perforation of the posterior laryngeal wall. The pharyngeal wall may be perforated and the cervical vertebrae eroded.

Living Objects.—These are rare, though among the older writings there are recorded instances of all sorts of small living animals finding their way into the fauces, pharynx, and esophagus (Poulet).

INFLAMMATION OF THE PHARYNX

Acute Pharyngitis.—Acute inflammation of the pharynx alone is a comparatively rare disease. It may occur in connection with an acute inflammation involving the soft palate, uvula, and the pillars of the fauces (acute faucitis). Acute inflammation of this region usually occurs in those already suffering from a chronic catarrhal inflammation of the faucial region, some slight exposure establishing a *locus minoris resistentiae,* as the result of which bacterial invasion, particularly streptococcus infection, occurs. Other predisposing causes are digestive disturbances, constitutional syphilis, rheumatism, and tuberculosis. Acute faucitis also occurs at the commencement or in the course of scarlet fever, measles, smallpox, erysipelas, and typhoid fever. It is sometimes epidemic. The disease frequently commences as a rhinopharyngitis. The larynx may be affected because of contiguity.

Symptoms.—A peculiar scratching sensation, followed by discomfort in swallowing and finally by pain, is complained of. There is sometimes a decided rise of temperature; a chill rarely precedes the latter. Headache, earache, tinnitus, and impairment of hearing may be present. Purulent otitis media may be a sequel. Speech becomes painful and difficult. A grayish viscid mucous, followed by a mucopurulent secretion, is present. Neuralgic pains in the ear through Jacobson's tympanic branch of the glossopharyngeal are sometimes complained of. Local examination reveals a velvetlike appearance and redness of the mucous membrane from hyperemia, and later on swelling of the mucosa. Sometimes a paretic condition of the soft palate exists Hyperesthesia is frequently marked. In mild cases resolution occurs in from two to four days. Some congestion and scanty tenacious discharge may continue for a time.

Treatment.—This, in the commencement, is largely medicinal (the use of diaphoretics, antipyretics, etc.). Duquesnel's aconitin (gr. $\frac{1}{500}$ every hour until the constitutional effects of the drug are obtained) is recommended (Bosworth). Salol is also valuable (Jonathan Wright). Inhalations of the steam of hot medicated solutions (tincture of benzoin, one dram to the pint) are very soothing. When the secretion appears, an astringent gargle or spray of chlorate of potassium and carbolic acid (2 per cent of the former and 1 per cent of the latter), or direct applications on cotton of 2 per cent solutions of chlorid of zinc, alum, tannin, etc., in glycerin are to be employed. Ear symptoms demand early attention. Inflation of the middle ear (Valsalva's or Politzer's method) should be practised. In case of catarrhal or purulent collections in the tympanic cavity, paracentesis of the drum membrane should be promptly performed. Prophylactic treatment consists in attention to the general health, the wearing of proper woolen underclothing, daily tepid or cold baths, and the avoidance of wet or chilled feet.

Subacute catarrhal pharyngitis is best treated locally by means of the daily application of a 2 to 10 per cent solution of iodin and iodid of potassium, with 1 per cent of carbolic acid.

Phlegmonous Pharyngitis (Erysipelas of the Pharynx).—This is of undoubted bacterial origin. The microorganisms probably enter through some slight traumatism of the upper epithelial layers. It occasionally occurs in connection with acute infectious diseases. Infection of the deeper layers of the mucosa and submucosa results in a grave form of the disease (**acute infectious phlegmonous pharyngitis**).

Symptoms.—The attack is sudden and violent and is sometimes accompanied by a chill. Considerable rise in temperature with rapid pulse is observed. Deglutition is difficult and painful. The throat is at first dry, afterward there is a tenacious secretion. The tongue is coated and the breath offensive; salivation may occur. The mouth is opened with difficulty on account of the spread of the inflammation to the tissues about the temporomandibular articulation. The peritonsillar tissues are particularly affected. The postnasal space may be invaded, producing obstruction. Dyspnea may result from extension and edema of the glottis. The submaxillary salivary and lymphatic glands are sometimes swollen and tender. The inflammation may subside in from four to fourteen days, or suppuration may occur. In the latter case the symptoms are greatly aggravated. Spontaneous rupture of the abscess may result in the passage of pus into the trachea. The pus may find its way into the esophagus, or burrow along the connective-tissue planes into the tongue and the mediastinum, or externally beneath the deep cervical fascia and into the submaxillary glands. Erosion of the great vessels may occur. General septic infection may take place.

Treatment.—A general tonic form of treatment, with stimulants, when indicated, should be followed. The local use of a 5 or 10 per cent solution of cocain may be employed before taking food. It may be necessary to resort to rectal alimentation. Hot antiseptic gargles and hot fomentations of carbolic acid applied to the neck in 3 per cent solution, are indicated. Free incisions should be practised as soon as fluctuation is detected. Even if the suppurative process is not reached at the first attempt, relief is afforded through drainage of the infiltrated tissues. The pus frequently finds an exit subsequently through the incisions. The cut is commenced laterally and made obliquely toward the median line. Frequent gargling with a hot antiseptic solution (2 per cent solution of boric acid) should follow the operation. Tracheotomy must be resorted to if edema of the glottis occurs. If suppuration finds its way externally, incisions in the lateral region of the neck must be made.

Ulcerative Pharyngitis.—This occurs as an ulceration of the superficial epithelial layers and lymphoid follicles. It frequently occurs in hospital attendants, pathologists, and medical students (**hospital sore throat**). It is marked by sore throat, high fever, and prostration. It is usually of short duration. The treatment consists in the use of antipyretics (phenacetin), gargles of a mild antiseptic solution (permanganate of potassium), and the occasional application to the ulcers of tincture of iodin on a small cotton swab.

Gangrenous Pharyngitis.—This is essentially a septicemic process which may supervene upon scarlet fever, diphtheria, measles, typhoid fever, smallpox, and phlegmonous pharyngitis. Black or greenish-blue spots appear. The breath is horribly fetid. The temperature is at first high; it may become subnormal. The prognosis is necessarily very unfavorable. The treatment consists in supporting measures and the local application of cleansing and disinfecting measures.

TUMORS OF THE NASOPHARYNX

Lymphoma (Adenoids).—This is essentially a disease of childhood. It consists of a hypertrophy of the lymphoid tissue (pharyngeal tonsil) in the vault of the pharynx. It develops in infancy, is frequently congenital, and may be hereditary. Inflammatory conditions are frequently the exciting cause. Nasal stenosis from hypertrophic rhinitis or deflected septum, or both, may be present.

Symptoms.—The leading symptoms are (1) excessive mucopurulent discharge; (2) an altered character of the voice from loss of the nasal sound, m, n, and ng being sounded as b, d, and g; (3) chronic otitis; (4) mouth-breathing and deficient air-supply; (5) a broadened and flattened contour at the root of the nose and a semi-idiotic facial expression. The hard palate is raised to an abnormally high level and the dental arch is narrowed. The transverse nasal vein crossing the bridge of the nose is sometimes enlarged (Spicer). In addition to these, there is disturbed sleep, headache, and in certain cases cough and asthma.

Diagnosis.—This is made by digital exploration and posterior rhinoscopic examination. In making the digital examination the lower portion of the septum is first identified and this traced until the growth is felt. Contraction of the muscles of the pharynx should not be mistaken for the growth. The posterior rhinoscopic examination is conducted with the tongue depressed and the palate relaxed. Cocain anesthesia will assist in the examination.

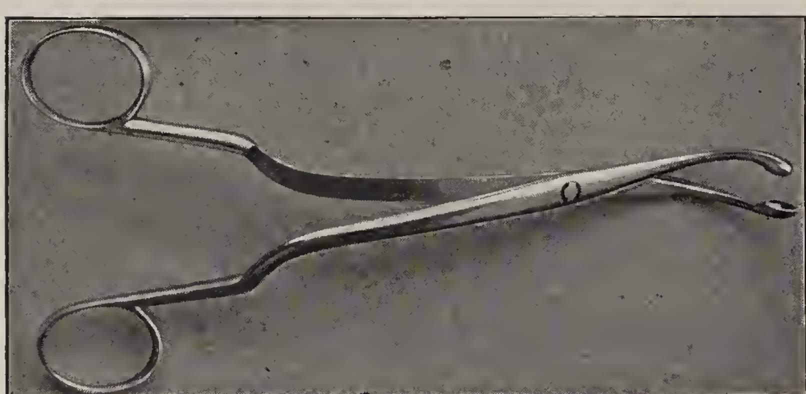


Fig. 341.—Cutting Forceps for Removal of Adenoids.

Treatment.—The use of astringent sprays will lessen the discharge, and perhaps slightly lessen the size of the growth. A combination of carbolic acid and tannic acid (carbolic acid, 1 grain; tannic acid, 40 grains; glycerin, 4 drams; water, $3\frac{1}{2}$ ounces) is useful for this purpose. The galvanocautery is advocated by some. Complete extirpation by operation is the best method of treatment. This is best accomplished by means of the cutting forceps (Fig. 341), aided, when necessary, by the cutting curet (Fig. 342). The child is anesthetized and placed in the dependent head position, if chloroform is employed; or secured to a chair and placed in the upright position if ether is employed (French). A mouth-gag (Fig. 337) is introduced and a palate retractor used as required. The mass of tissue must be completely removed. Hemorrhage is free at first, but ceases when the lymphoid tissue is removed and pressure applied. If necessary, the posterior nares may be plugged.

Fibromas.—These are sessile growths at first, though they may finally become pediculated. They usually occur in males at about the age of puberty. The growth springs from the periosteum of the basilar process of the occipital bone and from the body of the sphenoid bone.

Symptoms.—Repeated attacks of epistaxis, sometimes violent in character, usually occur early in the case. As the growth increases in size the pos-

terior nares become occluded and bilateral nasal stenosis results. This is followed by a characteristic facial expression. This expression increases until the broadening and flattening of the face become a well-marked facial deformity. Finally, the pressure of the growth from behind, and perhaps invasion of the antrum and ethmoid cells, causes protrusion of the globe (exophthalmos). A discharge of tenacious mucus or mucopus in the fauces and of a watery secretion from the nasal cavity occurs. This may be tinged with blood. Dyspnea from mechanic obstruction due to extension of the growth downward may take place.

Diagnosis.—This is made by digital and posterior rhinoscopic examination. The examining finger sometimes causes hemorrhage. The growth is dense to the touch. Inspection reveals an irregularly rounded growth of a light pinkish color. The bilateral stenosis is diagnostic.

Prognosis.—This is grave in proportion to the invasion of surrounding vital parts, and the dangerous nature of the operative procedures necessary for their extirpation, when they have attained large proportions. The tumors sometimes disappear by sloughing.

Treatment.—When of moderate size the growth may be removed by repeated applications of the galvanocautery, or at a single sitting by means of

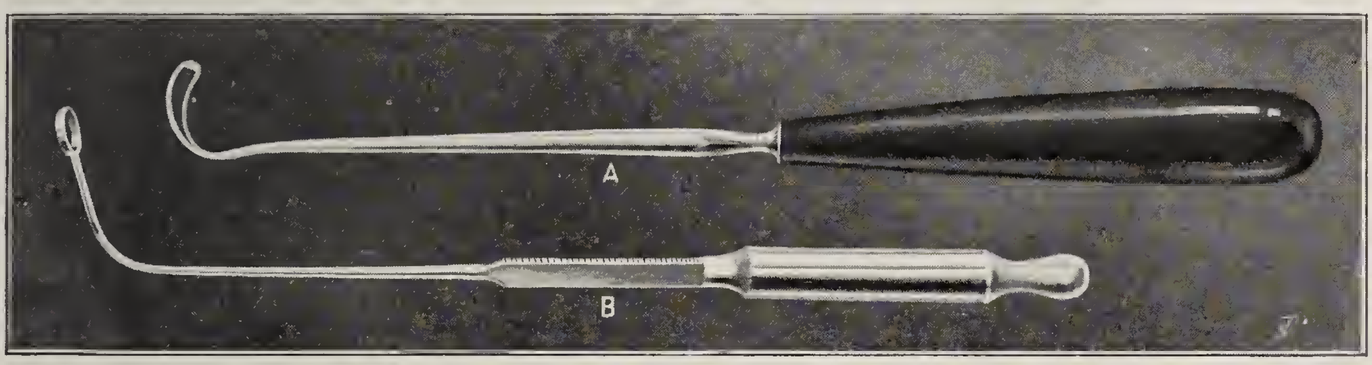


FIG. 342.—CUTTING CURET FOR THE REMOVAL OF ADENOIDS FROM THE NASOPHARYNX. A, Gottstein's curet; B, sharp ring-shaped curet.

the cold wire snare (Jarvis, Fig. 282). Piano wire (No. 5, or even larger) should be employed. The section should be made very slowly, to avoid hemorrhage. For larger growths separation of the two halves of the superior maxilla after sawing through the hard palate (see page 577) or temporary osteoplastic resection of the upper jaw may be required.

Myxofibromas.—These spring from the openings of the posterior nares. They occur more frequently in females than in males, and are generally observed between the ages of fifteen and thirty. The growth is generally nonvascular.

Symptoms.—The tumor is of comparatively rapid growth and gives rise to progressive unilateral nasal stenosis. There may be some hypersecretion. The voice is deprived to some extent of its normal nasal resonance and articulation is interfered with by the impingement of the growth on the soft palate. The growth may attain considerable size without giving rise to marked symptoms.

Diagnosis.—A myxofibroma is to be differentiated from a fibroma by its grayish-red appearance, greater mobility, and the absence of marked vascularity. Epistaxis does not occur and facial deformity is wanting. Myxofibromas occasionally recur after removal.

Treatment.—These tumors are usually easy of removal by means of the cold wire snare introduced through the nose, or they may be twisted off by the polypus forceps. Their removal may be facilitated by incision of the soft palate. The parts should be cocainized beforehand.

Chondroma.—This is exceedingly rare in this region. Its removal may be accomplished by temporary removal of half of the nose, division and separation of the upper jaw, or temporary resection of the latter.

Sarcoma.—This is of comparatively rare occurrence. The disease is observed as rounded masses, sometimes encapsulated, springing from the deeper layers of the mucous membrane that covers the basilar process of the occipital bone, the body of the sphenoid bone, the soft palate and pharyngeal wall, extending sometimes to the upper cervical vertebrae and invading the nasal cavity, orbit, zygomatic fossa, and anterior portion of the base of the brain. The growth increases more or less rapidly in bulk, and the posterior portion of the brain may be invaded by involvement and perforation of the basilar process. It may occur at almost any time of life.

Symptoms.—The symptoms are those of nasopharyngeal tumors in general, with the addition of the presence of a seromucous, ichorous, and offensive discharge, which vitiates the inspired air, impairs digestion, and thus leads to deterioration of the general health. Interferences with swallowing and breathing from mechanic pressure occur as the growth enlarges. Hearing is impaired by encroachment of the tumor upon the orifice of the Eustachian tube. Epistaxis occasionally occurs.

Diagnosis.—A grayish-yellow lobulated tumor with a soft pultaceous feel is present. The thin, watery, ichorous, and offensive discharge should always excite the surgeon's suspicion. The only certain means of diagnosis consists in the removal of a piece for microscopic examination.

Prognosis.—This is unfavorable. Small round-celled tumors grow rapidly as compared with the spindle-celled variety, but death finally takes place, either from the growth or from the operative attempt for its removal. A single authenticated instance of cure is recorded (Bosworth's).

Treatment.—Extensive radical operative procedures are generally useless. They frequently fail even to alleviate the sufferings of the patient, and many patients die on the table, or shortly after the operation. While still of moderate size, the cold wire snare is most applicable for its removal, as in fibroma. Wide access to the growth may be obtained by incising the palate. In larger growths, provided adjacent vital parts have not been invaded, the surgeon is sometimes justified in consenting to radical operation, though not always in advising it. In advanced cases involving the antrum, orbit, zygomatic fossa, or sphenomaxillary fossa, he should refuse to interfere in this manner.

Carcinoma.—The occurrence of carcinomatous deposits in the nasopharynx is less frequent than the occurrence of sarcoma. The symptoms and clinical course are similar to those of sarcoma. Microscopic examination, if a portion is removed for the purpose, will establish the diagnosis. Secondary involvement of the glandular and other tissues of the neck occurs early in the disease. The youngest patient recorded was thirty-seven; the oldest, seventy-five. Treatment, to be of any service, must be instituted early in the case and be radical in character.

Operations for Gaining Access to the Nasopharynx for the Removal of Tumors.—The Nasal Route.—The incision is made slightly to one side of the middle line of the nose. The lateral nasal cartilage and the nasal bone are divided on the same line. If more room is needed, the nasal process of the superior maxilla is divided from below upward, just in front of the lacrimal sac, the root of the nasal bone chiseled across, and the corresponding side of the nose thrown upward (Kocher). Or, the nasal cavity may be exposed by detaching the nose and turning it upward. Two incisions are made, one on each side of the nose, commencing at a point just internal to the lacrimal sac. These are carried downward to the junction of the ala nasi of each side with the lip, and are thence extended into the nasal cavity by cutting through the nasal bones and the nasal process of the maxilla. Finally, the septum is divided and the nose turned up (Lawrence).

The Palatal Route.—In this method the hard and the soft palate are divided and a portion of the former removed. A median incision is made down to the bone in the hard palate, and extended so as to bisect the soft palate and uvula. The mucoperiosteal soft parts are detached and turned aside, a transverse cut on each side facilitating this. The hard palate and a portion of the vomer are chiseled out in the shape of a quadrilateral piece of bone, and the posterior part of the nasal cavity and the nasopharynx exposed (Nélaton, Gussenbauer).

Annandale operated as follows: The mucous membrane of the lip is freely detached at its reflection on the jaw and the lip turned upward so as to expose the anterior nares. The bony septum of the nose is divided at its attachment to the superior maxilla with cutting forceps. A gag is now introduced and an incision is made in the median line of the hard palate down to the bone. An incisor tooth is extracted, a metacarpal saw introduced in the naris, and the hard palate sawed through the median line. If necessary, the soft palate is also divided. To gain additional room, the lip and cheeks may be detached at their reflection on the gums, and both halves of the upper jaw chiseled through transversely outward and backward from the anterior nares (Kocher). The two halves of the upper jaw are now drawn apart with sharp hooks, the mucous membrane of the floor of the nose divided, the vomer drawn aside, and the projecting turbinated bones excised. The tumor is now completely exposed and removed through the gap. Ligation of both external carotid arteries should precede the operation on the jaw.

The Maxillary Route.—The method of **osteoplastic resection** of the upper jaw gives good access to tumors attached to the basilar process of the occipital bone and its neighborhood. Both external carotid arteries may be ligated preliminarily. The operation is the same as for typic resection of one-half of the upper jaw, except that the soft parts of the face are not detached from the bone after the skin incisions are made. The frontal process of the malar bone must be divided through a separate incision. The separated half of the jaw is to be turned back with the attached soft parts. After removal of the tumor the parts are restored and the soft parts sutured.

In all operations of the kind described the venous hemorrhage is sometimes excessive. Kocher recommends that a sixth of a grain of sulfate of morphin be given half an hour before the operation, and a minimum amount of chloroform administered through a tracheotomy tube, with the patient sitting upright.

For operations in the nasopharynx French recommends that the patient be secured to a chair, the back of which is lowered, and that ether be administered. The chair is then carefully raised until the patient is in the upright position, when the operation is proceeded with.

THE EAR

Only those common affections of the ear coming under the observation of the general surgeon will be considered in this connection.

Injuries of the Auricle and Cartilaginous Auditory Meatus.—Incised wounds of the auricle are usually followed by retraction of the skin layers, leaving the cartilage more or less exposed. While there is no objection to suturing both the cartilage and the skin, carefully applied fine silk sutures at the skin edges alone will suffice. Care should be taken in applying the dressings to maintain the proper shape of the parts, or serious deformity may result. Even if but a slight connection of skin is maintained between the partially severed portion and the auricle, the attempt should be made to restore the former, since parts even completely severed have reunited when promptly replaced.

An unsightly slit is sometimes left in the lobule by the tearing out of an earring. This also happens from slow ulcerative action, the weight of the earring slowly separating the lobule. Freshening the surfaces of the gap and suturing give uniformly good results in the so-called **coloboma of the lobule.**

Frost-bites of the auricle are of not infrequent occurrence, through which small portions of the upper border are lost. Attempts at plastic replacement have not heretofore met with very encouraging success.

Othematoma of the auricle is a peculiar affection occurring particularly in the insane. It consists of an isolated subperichondrial effusion of blood near the free edge of the auricle, at either its anterior or its posterior wall, a flat convex swelling resulting. Coagulation does not take place, in this respect the effusion resembling cephalhematoma. In the insane the presence of an othematoma is frequently made the basis for accusations of maltreatment against those in charge. It is due, in all probability, to vasomotor disturbances. **Treatment** by massage should first be tried. This failing, aseptic incision and drainage will result in prompt cure, the loosened perichondrium very readily reattaching itself to the cartilage.

Injuries of the Bony Parts of the Ear.—Isolated fractures of the bony auditory meatus sometimes occur from forcible impact of the condyle of the lower jaw, the result of a fall on the chin. **In fractures of the base of the skull in the middle fossa** the fissure passes to the apex of the petrous portion of the temporal bone and thence to the lateral wall of the skull. The usual signs of fracture of the base of the middle fossa, with rupture of the membrana tympani, *i. e.*, hemorrhage from the ear and the escape of cerebrospinal fluid, are present. In the differential diagnosis of fractures in this region and injury to the drum membrane alone, the amount of bleeding, together with the presence of sugar in appreciable quantities in whatever serous oozing is present, is to be considered. In case of compound fractures, even considerable quantities of brain matter from the lateral lobes of the cerebellum may escape without marked disturbance, owing to the absence of important function in this locality. Injuries of the petrous portion of the temporal bone by direct force, *e. g.*, by projectiles, give rise to **compound**

fractures, as well as to **fatal hemorrhage** either from the internal carotid artery as this vessel passes through the carotid canal, from the transverse sinus, or from the middle meningeal artery from extension of the fissure to the upper margin of the squamous portion of the temporal bone. Careful packing of the wound will usually suffice to arrest the hemorrhage, if this comes from the sinus. In some cases of rupture of the internal carotid not proving immediately fatal, the corresponding common carotid artery has been successfully ligated. In others, however, this has failed, even when supplemented by ligation of the other common carotid. The uncertainty of this procedure is explained by the freedom of the arterial cerebral circulation through the circle of Willis, as derived from the terminals of the vertebrals when the common carotids are ligated. In cases of secondary hemorrhage, therefore, following injury in this region, as well as in cases of hemorrhage resulting from erosion of the internal carotid occurring in the course of caries of the petrous portion of the temporal bone, the preferable course is to pack the canal very tightly with iodoform gauze.

Fig. 343.—Tubular Ear Speculum.

In order to guard as much as possible against septic meningitis and encephalitis in injuries in this locality, every aseptic precaution, including antiseptic irrigation and sterile protective dressings, should be taken.

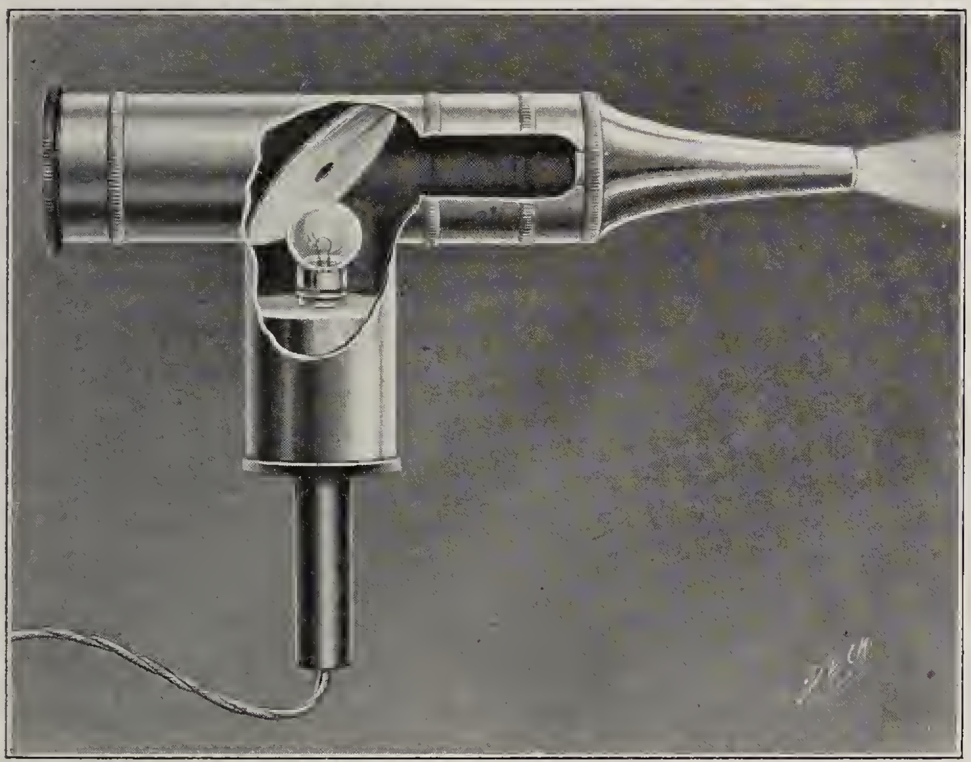


Fig. 344.—Electric Light Otoscope.

Both the facial and the auditory nerves may be injured in fractures of the petrous portion of the temporal bone. These injuries are surgically irreparable. Spontaneous restoration of function may take place, however.

Foreign Bodies in the External Auditory Canal.—Children often introduce such articles as peas, beans, and buttons into the external auditory meatus. The foreign bodies most frequently found in adults are cotton plugs, placed in the ear with the delusive belief that these will prevent "catching cold," the presence of the cotton being forgotten. The cerumen and cotton combine to form a dense hard mass completely filling the canal.

Plugs of cerumen having their origin in excessive secretion of cerumen from chronic inflammation of the ceruminous glands may give rise to the symptoms of true foreign bodies in the ear, the mass obstructing the canal and producing impairment of hearing; in some cases they may cause annoying and persistent tinnitus.

Foreign bodies and masses of cerumen are usually easily discovered by inspection, the auricle being retracted so as to straighten the canal by grasping it at its upper edge. If the foreign body is small, it may be necessary to use an ear-speculum (Fig. 343). The common tubular ear speculum made of metal, with the interior polished to improve the illumination, serves an excellent purpose. The electric light otoscope is a very useful instrument for examining the deeper parts of the canal and the drum membrane (Fig. 344). In the case of the common tubular speculum the patient is seated with the ear to be examined opposite a window, and the light reflected with a head band mirror. If the direct rays of the sun are used or an artificial source of light is employed, the polished interior of the tubular speculum is somewhat dazzling to the examiner, and the instrument with dull finish, or one made of hard rubber, is to be preferred. In examining for foreign bodies the surgeon should not be misled by the brownish layers of cerumen lying against the walls of the auditory meatus. In the case of a foreign body the inspection will sometimes reveal whether or not a space is left between the latter and the wall of the meatus, into which an instrument may be introduced for the purpose of effecting the extraction from within outward.

A probe, if employed at all, should be used with the greatest care. Its use without the aid of the speculum gives but very little information, since its contact with the bony walls closely covered with skin and periosteum will greatly resemble the touch of a foreign body.

Foreign bodies should always be removed, for, though exceptionally they may remain innocuous for a time, they will eventually set up irritation, and finally suppuration, which will extend to the tympanum and impair the function of hearing, and lead to destructive changes in the bone itself; the latter may even threaten life by setting up meningitis. It is as dangerous, however, to attempt to extract these bodies roughly without proper illumination as it is to permit them to remain.

Removal of Foreign Bodies from the External Meatus.—Small foreign bodies which do not completely fill the meatus are best removed by forcible syringing with a large sized piston syringe with ring pieces for firm grasping (Fig. 345). The syringe is worked with the right hand, the left grasping the auricle and retracting it upward and backward so as to straighten the canal and give free access and exit to the lukewarm water employed.

In the case of foreign bodies deeply placed the wire curet or a fenestrated ear spoon sometimes accomplishes the purpose with facility. If a space exists between the foreign body and the meatus, it will usually be found in the direction of either the upper or the lower wall. A small hook introduced flatwise and then turned so as to engage the foreign body is often successful. An extracting instrument may be improvised from a hairpin. Whatever form of instrument is employed it must be introduced with strong pressure against the wall of the meatus or canal, so as to gain as much room as possible, as well as to lessen the friction as it glides past the foreign body. Foreign bodies swollen by attempts to flush them out with water, or from secretions excited by their presence, may be reduced in size by contact with glycerin for some hours. The instrument may then be introduced alongside the softened cortical layers. Softened beans will sometimes split longitudinally and admit of easy extraction.

In the case of nervous children, and in any case in which much pain is caused

by the manipulation, the patient should be anesthetized. Hard impacted foreign bodies may even require temporary loosening of the auricle and cartilaginous meatus through an incision made from behind. This usually permits direct access to the foreign body. Such incisions should be made with every aseptic precaution, since suppuration in this locality may involve destruction of the membrana tympani.

Ceruminous plugs are best removed by forcible syringing. In case these should prove obstinate they may be softened by the previous application of a weak solution of carbonate of soda in water and glycerin.

Inflammation of the External Ear.—The usual inflammatory affections of the face and scalp, such as **eczema, impetigo,** etc., attack the auricle. **Erysipelas** gives rise to the formation of vesicles at the upper edge of the auricle. Severe phlegmonous inflammations, however, are rare, on account of the absence of loose connective tissue. Furuncles are also rare, on account of the superficial location of the hair-follicles.

Lupus may extend from the cheek to the ear. This usually occurs in the exfoliating form of the disease. The cicatricial atrophy may result in the disappearance of nearly the entire auricle. **Lupus of the lobule** has been described as an isolated disease in which the whole substance of the lobule is converted into pale red tissue. In some cases the disease is arrested only by the removal of the lobule.

Otitis Externa.—External otitis appears in the following forms:

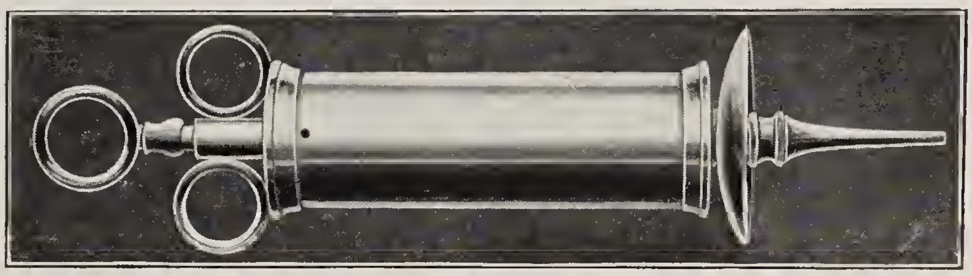


Fig. 345.—Ear Syringe.

1. **Eczema** of the external auditory meatus, occurring specially in strumous children and accompanying eczema of the skin of the external ear. The vesicles discharge a serous fluid, a part of which escapes from the ear while some remains and dries in hard crusts on the walls of the canal.

2. **Furuncle.**—This commences with swelling of the skin lining the external auditory meatus, and develops with violent pains as the thin skin is tightly stretched on the underlying perichondrium and periosteum. The local symptoms partake of the character of periostitis. There is diffuse swelling with absence of localized elevation corresponding to the site of infected sebaceous glands or hair-follicles, so characteristic of the affection as it occurs elsewhere. The furuncular character of the lesion, however, is established by the occurrence of an isolated connective-tissue necrosis, unless this is anticipated by early and free incision, which always gives prompt relief. **Furuncles** should be incised early. The curved and pointed bistoury, or the tenotome, best serves the purpose for the incision. If an abscess of the ear drum or a collection of pus behind the tympanum, as shown by a bulging of the latter, occurs, the puncture is best made with the point of a cataract needle. Illumination, both for the purpose of diagnosis and for the guidance of the instrument in case of puncture, is here absolutely necessary.

3. **Traumatic suppuration** following injuries or due to the presence of foreign bodies.

4. **Secondary suppuration** consequent upon suppurative perforation of the membrana tympani as a result of otitis media.

Otitis media, which, with **otitis interna**, belongs essentially in the domain of the otologist, will be only superficially considered here. Not only is the drum membrane perforated, but the mastoid cells are also affected. The resulting caries is not necessarily tuberculous, though it may be of this character if the original suppuration in the tympanic cavity was tuberculous. The latter, however, is usually metastatic, and occurs especially after measles and scarlatina. Finally, a true tuberculous myelitis may occur in the mastoid process without preceding disease of the middle or external ear.

Tumors in the Region of the Ear.—Deformities of the Auricle.— So-called polypi of the external auditory meatus are very frequently made up of granulation tissue originating in the suppurating surfaces of an external otitis, or in cases of otitis media, from the mucous membrane of the tympanic cavity. In the latter case the tumor grows through a large defect in the membrana tympani and projects into the external auditory meatus. Sometimes this granulation tissue becomes covered with a layer of epidermis, and the name of **granuloma** is given to the resulting tumor. These growths occasionally persist in this shape for a long time after the suppuration

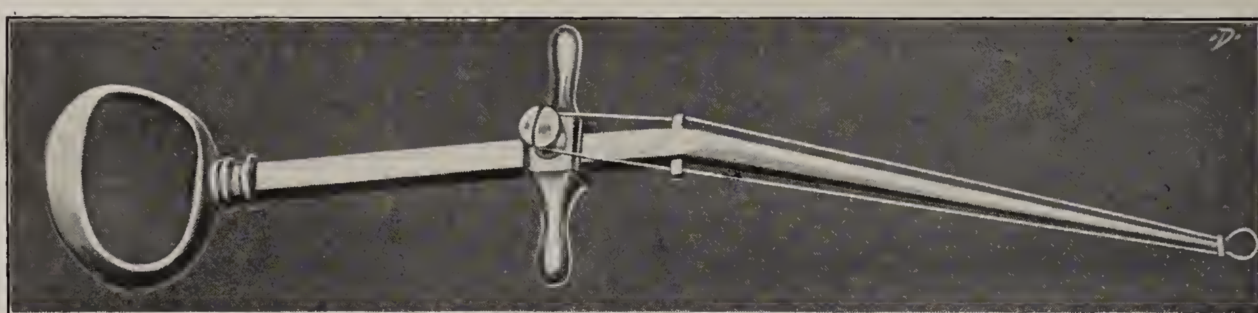


Fig. 346.—Wilde's Aural Polypus Snare.

has ceased, and from the fact that they finally become pediculated the name of "aural polypi" is more or less justified. They are even said to have become finally the seat of angiosarcomas.

When these granulating masses are sessile and soft, they are to be treated by scraping and cauterization; when solid, they will require excision. Those belonging to the pediculated variety are easily and satisfactorily removed with Wilde's snare (Fig. 346). Removal of the granula or polypus, however, will not improve the hearing in cases in which the growth follows otitis media, since the preceding suppurative process in the middle ear has already done its damaging work.

Both benign and malignant growths occur at the auricle and in its neighborhood. Dermoids are found springing from the upper branchial cleft; their favorite location is either in front of the auricle or behind it. They are less frequently found at the upper or the lower portion of the latter. They vary in size from a hazelnut to a hen's egg. Those of smaller size, and particularly those lying in front of the auricle, are usually very superficial and are often mistaken for simple atheromas. Those extending into the deeper structures are somewhat difficult of removal.

Auricular appendages have already been referred to in the section on tumors. They are connected with the processes of development, and occur

not infrequently with macrostoma. They are generally found at the anterior edge of the tragus. In addition to those containing a nucleus of cartilage, others have been found with a small opening corresponding to an inversion of the epidermis. These skin-covered remnants of cartilage have also been found over the sternomastoid (L o s s e n). They have been found springing concurrently from both sides. They may be easily and safely removed.

Angiomas occur as congenital tumors at the auricle and may give rise to dangerous symptoms in connection with pregnancy (see page 227). Of benign tumors, atheromas, enchondromas, and fibromas are only occasionally found in this region; they rarely develop to an excessive size. The last named, together with a condition approximating elephantiasis, attacks by preference the lobule.

Epithelial carcinoma sometimes attacks the auricle. It occurs as a flat ulcer and may finally destroy the auricle. It develops gradually, the destructive process is slow, and the prognosis in case of early and wide extirpation is comparatively good. Lymphatic glandular involvement takes place in the parotid region, behind the angle of the jaw, and at the anterior edge of the sternomastoid.

Efforts to correct the deformity following amputation of the ear by plastic operations (**otoplasty**), as well as those designed to supplement congenital defects, have met with but indifferent success. While efforts to replace the lobule by skin flaps from the neighborhood are fairly successful, the complicated shape of the auricle has heretofore defied, to a great extent, the best efforts of plastic surgery. More or less improvement, however, may sometimes be obtained.

Projecting ears, in which the auricle projects abnormally, may be corrected by the removal from the auricle of an elliptic shaped portion of proper dimensions. The sutures are so placed as to include both skin and cartilage on the outer aspect, and the skin alone on the inner aspect.

Mastoiditis.—This is usually due to an extension of infection from the middle ear. Primary mastoiditis is rare. The pathologic changes consist of thickening of the lining membrane of the cells of the mastoid, followed in some cases by a deposit of new bone, which may finally lead to complete obliteration of the cells. In other cases necrosis occurs, with the formation of a sequestrum. Or, gradual disintegration may occur, with discharge of detritus and pus through the external ear. When the evacuation takes place externally, this may occur either behind the ear, into the external meatus, or into the digastric fossa. When internally, the fluid finds exit either through the roof of the antrum or through that of the tympanic vault, into the middle cranial fossa or into the posterior cranial fossa along the groove which lodges the lateral sinus (**sinus thrombosis,** see page 584).

The external discharge of pus does not relieve the case of its dangers, particularly in children, since intracranial infection may subsequently take place through the incompletely ossified sutures. Invasion of the cranial cavity may lead to **diffuse septic meningitis** (see page 457) or to a circumscribed inflammation and **epidural abscess.** Finally, the intracranial contents may become infected through the free anastomosis of the vessels of the parts, and thrombosis of the lateral sinus (see page 464) or abscess of the brain substance follow (see pages 459, 462, and 586).

The **symptoms** of mastoiditis are intense pain over the mastoid, which is most severe at night, more or less constitutional disturbance, and tenderness on deep pressure, particularly over the posterior margin of the canal. A previously existing aural discharge is diminished or ceases altogether. In children tumefaction behind the auricle may be present. Perforation of the cortex is announced by the presence of a purulent material between the overlying soft parts and the bone. Invasion of the cranial cavity is accompanied in the case of sinus thrombosis by sudden elevation of temperature, followed by a decided fall in temperature; the temperature curve becomes irregularly intermittent thereafter. The symptoms of general sepsis are present. Septic emboli may become lodged in the viscera, particularly in the lungs. If the lateral sinus is the seat of thrombosis, the latter may extend into the internal jugular vein, with tenderness and tumefaction along the course of the latter. In cases of diffuse septic meningitis there is intense headache, intolerance of light, constant high temperature, and nausea and vomiting. The pulse is generally rapid when the meningitis is basilar, which condition is usually the case in otitic meningitis. Local paralyses, particularly those involving the distribution of the third and sixth nerves, appear early. Rigidity of the muscles of the neck is an early and characteristic symptom. In cases of localized meningitis the constitutional symptoms are less severe, the headache localized, the paralytic symptoms delayed in their appearance, and the vomiting, intolerance of light, and rigidity of the muscles of the neck absent.

Treatment.—Whether or not an aural discharge is present, free drainage through the canal should be insured by incising any bulging segment of the drum membrane. This is followed by irrigation with boric acid solution and the application of ice, if the case is not advanced. The presence of the Streptococcus pyogenes in the discharge constitutes an indication for immediate opening and drainage of the mastoid, even in the absence of definite symptoms of mastoiditis. The presence of this microorganism in the discharge resulting from an exploratory puncture of the ear drum likewise indicates the operation. Even in the absence of a streptococcus infection efforts to abort the attack should not be continued, at the very outside, beyond forty-eight hours from its commencement. The mastoid cells should be freely opened and the infected area exposed by removal of the entire cortex and drainage of the middle ear through the opening secured.

Trephining the Mastoid; Antrectomy.—The incision commences at the top of the auricle in the line of the hair, and is curved first backward, then backward and downward, and finally downward and forward to terminate at the posterior part of the apex of the mastoid (Fig. 347, 1 to 2). The incision is carried directly down to the bone. If the aponeurosis of the sternomastoid comes into view at the lower angle of the incision, it is to be detached from the bone by means of blunt scissors, the instrument hugging the bone closely while this is being done. In children the stylomastoid foramen, owing to the undeveloped condition of the mastoid process, is laterally placed, instead of lying on the under surface of the base of the skull, so that deep dissection carried below a point on a level with the middle of the meatus exposes the facial nerve to injury.

The bone is thoroughly cleared; the auricle is detached by blunt dissection, and, together with the skin lining, the meatus is pushed well forward and held

by a retractor. If a sinus the result of a spontaneous rupture is present, this is enlarged and followed; it will generally lead to the mastoid antrum. If no sinus is present, the upper limit of the external auditory canal is located; under no circumstances must the opening in the bone be carried above the level of this point. The cortex over the antrum, the level of which corresponds

Fig. 347.—Lines of Incision for Mastoiditis, Brain Abscess, and Sinus Thrombosis. 1 to 2, Incision for mastoid operation; 2 to 4 and 2 to 5, incisions for brain abscess; 3, line of incision for sinus thrombosis.

with the upper half of the orifice of the external meatus, is removed with the chisel. The junction of the antrum with the middle ear corresponds with the posterior half of the segment of the orifice of the external meatus above mentioned. The further application of the chisel is made so as to deepen the

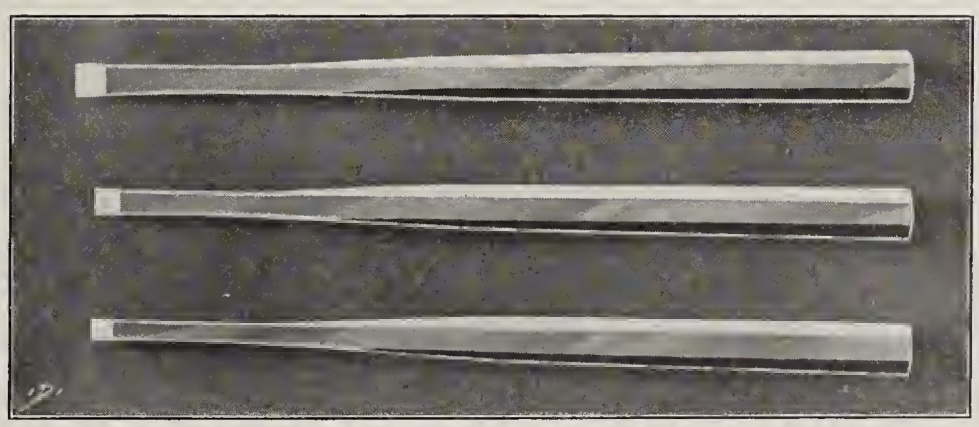


Fig. 348.—Mastoid Chisels.

opening, a bony funnel being formed. The larger pneumatic spaces are soon opened, and the antrum reached at a depth varying from an eighth to three-fourths of an inch. Occasionally it is obliterated by hypertrophic sclerosis. As the cancellous structure is reached the gouge is substituted for the chisel and worked as much as possible with the hand, the use of the chisel being

avoided. Entrance to the antrum is known by the fact that a probe, slightly bent at its tip, passes into the middle ear. The antrum and passage to the middle ear are now thoroughly curetted. If granulation tissue is present the curetting should be carefully proceeded with; this sometimes springs from the dura lining the cerebellar fossa and covering the sigmoid sinus, and projects into the mastoid cells. All pus and debris being cleared away, the bony cavity is packed with sterile gauze and the upper portion of the wound sutured with silkworm-gut.

Injury to the lateral sinus is best avoided by keeping well forward toward the auricular attachment, and above the level of the lobe of the ear. If the dura of the middle cranial fossa is exposed, the remainder of the chiseling must be done at a lower level, in order to reach the mastoid antrum. Hemorrhage from an injury to the lateral sinus can be controlled by tamponing with iodoform gauze, the operation being completed by enlarging the opening in the opposite direction.

In children the mastoid cells are but imperfectly developed, almost the entire process being occupied by the antrum. Great variations exist in the adult mastoid process, in 20 per cent of which there is an absence of pneumatic cells; in 38 per cent the opposite condition obtains, *i. e.*, the absence of diploe. In some cases the upper half of the mastoid process is pneumatic, the lower half containing diploe.

In the absence of the antrum, or when no pus is present in this cavity, the apex of the mastoid and the vertical group of cells should be explored. When the latter are well developed and become infected, perforation is liable to occur on the inner side of the apex, followed by suppuration in the digastric fossa and under the sternomastoid muscle.

In cases of long-standing discharge, with extensive disease in the tympanum, and particularly where previous operations have failed, the auricle should be temporarily detached, and, in addition to the outer wall of the antrum, the upper and outer portion of the bony meatus and the remains of the membrana tympani and ossicles should be removed (S t a c k e).

Abscess of the Brain.—This may give rise to no characteristic symptoms, except constant headache, progressive weakness and dullness of intellect, until it has attained sufficient size to press on some portion of the motor area. The temperature may remain normal or become but slightly elevated. Invasion of the motor tract will give rise to definite localizing symptoms in many cases (see page 467). It should be borne in mind that two or more intracranial complications of otitic origin may be present at the same time.

Steatomas of the mastoid consist of epithelial collections in the cells. They may excite hyperplastic inflammation, sclerosis, and obliteration of the trabeculae, in some cases converting the mastoid antrum, tympanic cavity, and external bony canal into one cavity, with sclerosis of the mastoid cortex.

THE SALIVARY GLANDS

Injuries of the Parotid Gland.—These may result from blows, stabs, or gunshot wounds; they may also occur in the course of operations. Healing usually takes place promptly. The occurrence of a salivary fistula is generally

preceded by the accumulation of saliva beneath the suture line. Pressure on this, abstinence from chewing and talking, and a fluid diet taken in small quantities, usually suffice to prevent a fistula. Even when the latter occurs it is not usually persistent.

Injuries of the Parotid (Stenson's) Duct.—These usually result from sword slashes or stab wounds, and occasionally from operation wounds. The flow of saliva from the wound usually announces the nature of the injury. This may be verified by passing a probe from the normal orifice in the mouth to and out of the wound in the cheek. If the wound of the cheek is a penetrating one and the external portion heals, the centrally placed divided end is kept patent by the saliva flowing into the mouth. If the wound is nonpenetrating and allowed to heal as such spontaneously, a salivary duct fistula is sure to follow.

Treatment.—In order to prevent a fistula of Stenson's duct in nonpenetrating wounds of the cheek primary union must be secured; the duct itself must be sutured separately with fine catgut. The sutures should not encroach upon the lumen of the duct. In penetrating wounds the skin alone is sutured, the saliva being allowed to flow into the mouth through the wound in the mucous membrane. In contused and lacerated wounds involving Stenson's duct, in which primary union is improbable, an immediate communication should be made in order to secure an internal salivary fistula; the latter will serve all the purposes of a normal duct.

In the after-treatment of injury of the parotid duct the secretion of saliva and movements of the jaw should be restricted as much as possible.

A permanent fistula of Stenson's duct results when the wound heals with fusion of the mucous membrane and skin at the site of the injury, or when the peripheral portion of the duct is occluded and the central portion terminates externally. Loss of substance of the duct itself is also sometimes present. Undermining of the surrounding parts takes place in some cases and the saliva discharges by several small openings. The fistula is usually situated in the buccal division of the duct. The **diagnosis** is generally made by the discharge of saliva upon the cheek, and in some cases it may be verified by probing.

Treatment.—When the proximal end is still pervious, cauterization with the solid stick of nitrate of silver or the use of the actual cautery should be tried. If the peripheral end is impermeable to probing and an injection of a colored solution from the oral opening fails to appear at the fistulous opening, a spontaneous cure is not possible, and operative measures must be resorted to. The simplest of these is to convert an external fistula into an internal one. The cheek is perforated somewhat obliquely by a trocar passed from the cavity of the mouth to the site of the fistula. A small drainage-tube is passed along the canal thus formed, its inner end projecting into the cavity of the mouth; its outer end is cut off obliquely so as to receive the saliva, which it conducts into the mouth. The tube is removed in about ten days. A substitute for the occluded peripheral portion of the duct having been thus formed, the fistula either closes spontaneously or is cauterized or sutured (Kaufmann). The method by double puncture consists in first excising the fistula for half the thickness of the cheek, and passing a silk ligature through the remaining portion so as to include about $\frac{3}{8}$ of an inch of tissue. The ligature is tied tightly from the inside of the mouth. The included bridge of tissue

sloughs and an internal opening of the fistula is provided (Deguise). The external wound is sutured. These measures failing, the central end may be dissected out and implanted into the mucous membrane (Langenbeck). In the absence of sufficient length of the duct to accomplish this a new duct may be formed from the mucous membrane (Nicoladoni, Braun).

Foreign bodies sometimes find their way into the salivary excreting ducts. A bristle from a tooth-brush, small fish-bones, and hairs have been found in Stenson's duct. Large foreign bodies, such as the cereals, seeds of fruit, etc., are much more frequently found in the submaxillary duct. Inflammatory conditions, or, if the foreign body is not forced out, abscesses and fistulas follow. Sometimes the foreign body is not discovered until an incision is made for the relief of an abscess. The **treatment** consists in removal of the foreign body by forcing it toward the orifice, or exposing it by an incision through the mucous membrane. If the foreign body has found its way to the submaxillary gland, the latter may become so altered by inflammatory conditions as to require removal.

Salivary Calculus.—Salivolithiasis is of relatively infrequent occurrence. It occurs most often between the ages of twenty and forty. Men are more often affected than women. Salivary calculi are most frequently found in Wharton's duct, though they likewise occur in the submaxillary gland, in the sublingual duct, and in the sublingual gland. The calculi vary in size from a grain of sand to a split pea, or even a hazelnut. More than one may be present. In composition they usually consist of calcium carbonate with the addition of calcium phosphate, soluble salts, and organic matter. The essential pathologic factors in the etiology of salivary calculi are foreign bodies (particles of food, fragments of tartar from the teeth, etc.) and bacterial infection.

The **symptoms** vary with the size of the calculus, its location, and the occurrence of suppuration. In the absence of the latter but slight discomfort may be present. Retention of saliva lasting for several hours after a meal, accompanied by pain and discomfort ("salivary colic"), is characteristic of a calculus in Wharton's duct. A hard nodule in the floor of the mouth, with difficulty in chewing, swallowing, and speaking, is usually present. If suppuration occurs, the abscess frequently discharges into the mouth, the calculus escaping at the same time; the latter is rarely discharged through the normal orifice of the duct. The stone may give rise to pressure necrosis and escape through the opening thus made. With the occurrence of suppuration the corresponding gland becomes infected, giving rise to a painful swallowing. Phlegmonous cellulitis of the neck, resembling Ludwig's angina, may supervene. Spontaneous external discharge of suppurative collections may lead to salivary fistula. The diagnosis may often be confirmed by probing the duct. The affection is to be differentiated from inflammation of the duct, from alveolar abscess, particularly in cases in which the abscess develops about the submaxillary gland, and from syphilitic and tuberculous disease, actinomycosis, and malignant disease. The x-ray may be useful in the diagnosis.

The **treatment** consists in evacuation of the abscess, removal of the calculus, and, in the case of the submaxillary and sublingual gland, the removal of these if a number of calculi are present and are difficult to remove, or the gland is the seat of miliary abscesses. Simple infection of the gland is not an indication for its removal. When the stone is situated in the duct, it should be removed

through the mouth; if in one of the salivary glands, it must be attacked from the outside.

Inflammation of the Salivary Gland (Sialadenitis).—This is usually caused by infections from the cavity of the mouth. Acute primary inflammation of the salivary glands is rare with the exception of the acute epidemic form (mumps). This affection derives a surgical importance from the **orchitis** which develops as a complication, and for which no satisfactory explanation has been given. Atrophy of the testicle occurs in about one-third of the cases (Kocher). Abscess occasionally forms. Oophoritis, mastitis, vulvovaginitis, prostatitis, and cystitis are other complications of surgical interest. Acute secondary sialadenitis results from foreign bodies, calculi, and septic conditions following injuries. It is not an infrequent complication of typhus; it also occurs in other infectious febrile states (scarlet fever, pneumonia, variola, pyemia, septicopyemia, etc.). It likewise develops after operations, particularly abdominal section (not necessarily operations on the ovaries, as was formerly believed). Here, as in the case of the febrile conditions, it is also due, in all probability, to infection from the mouth, since it has been shown (Pawlow) that, after abdominal section, as in the febrile state, there is a cessation or diminution of the salivary secretion. To this is to be added, as increasing the *locus minoris resistentiae*, the dryness of the mucous membrane of the mouth.

The **symptoms** of parotitis are fever, swelling of the gland, radiating pains, and tenderness. The swelling is first seen below the angle of the jaw, but finally extends from the middle of the cheek to the mastoid and lower temporal regions. The lobule of the ear becomes prominent and is elevated; the appearance is characteristic. The parts are intensely tender, especially when attempts are made to move the jaw, and the radiating pains become intense. The skin becomes red and edematous and the superficial veins are dilated. The hearing may become affected by compression of the external auditory canal. If the symptoms continue to increase beyond the third or fourth day, suppuration will probably occur. Extensive abscess formation may be present without palpable fluctuation, on account of the unyielding overlying fascia. Perforation may occur into the external auditory canal and purulent otitis media result. Burrowing may take place behind the pharynx and esophagus and into the mediastinum, rupture finally taking place into the air-passages. Infection may travel along the vessels and nerves and reach the interior of the cranium. Cerebral complications may also arise through the medium of venous thrombi. Thrombosis of the jugular vein and sigmoid sinus may occur.

Involvement of the submaxillary gland is comparatively rare, and extensive suppuration here is the exception rather than the rule. When this does occur, it resembles in its course Ludwig's angina.

Sialadenitis affecting the submaxillary and sublingual glands occurs in nursing children. Suppuration is the rule, the pus escaping through the excretory ducts and breaking through the skin and escaping externally.

The **treatment** of inflammation of the salivary glands consists in prophylactic cleansing of the mouth of a patient who has undergone an operation, or of one seriously ill with a febrile affection. The boric solution, with the addition of thymol, gaultheria, and tincture of myrrh, applied with gauze, is useful. With the development of the disease ice is to be applied to the parts for two or three days. If no improvement follows this treatment, and the violent symp-

toms persist, a free incision should be made through the fascia and the gland further exposed by blunt separation with a grooved director, or the blunt blades of an artery clamp. In making the incision in the case of the parotid gland the facial nerve is to be avoided. Diffuse suppuration and perhaps necrosis may be revealed. The parts are to be curetted, carefully cleansed, and a drainage-tube and an iodoform gauze tampon introduced. Early operative interference, in these cases, gives the best results.

The sialadenitis of nursing children is to be treated by incision and drainage.

The **"inflammatory tumor"** of Küttner is a chronic interstitial inflammation of the submaxillary salivary gland. The gland increases in size to a hen's egg, or becomes larger, and is more or less adherent. Tenderness is not marked. The swelling is difficult of differentiation from malignant tumors occurring in this region, and for this reason, as well as the fact that this tumor tends to extend to the surrounding tissues, excision is advisable.

Inflammation of the principal excretory ducts of the salivary glands (**sialodochitis**) has been observed in the duct of the parotid more frequently than in Wharton's duct. Injuries and carious teeth are said to be the causes. The chief symptoms are acute retention of saliva, the formation of a salivary tumor, with cessation of the latter coincidental with an increased flow of saliva as the obstruction is overcome. The retention is due to a fibrinous plug. The orifice of the duct is red and projecting, and pressure along its course will express a drop of pus or a fibrinous plug. A permanent dilatation of the duct may follow and the gland itself may become involved. The **treatment** should be primarily directed to the removal of the cause. The occasional passage of a probe and the injection of an antiseptic solution afford relief. The disease is not usually amenable to curative treatment except by the operation of splitting up the duct, which should be performed when the attacks of retention are painful and frequent.

TUMORS OF THE PAROTID AND SUBMAXILLARY GLANDS

In addition to salivary cysts, **chondroma, adenoma,** and **sarcoma,** or combinations of these, are observed. Those of the parotid gland are the most frequent.

Chondroma.—The cartilage of the first branchial arch lies at the site of the subsequently developed parotid, and fetal cartilaginous structure is inclosed during the formation of the gland (Lücke, Cohnheim). Chondroma of the submaxillary gland results from proximity of the second branchial arch. These tumors are globular in shape and present nodulated surfaces. Their growth is very slow and painless. After being in existence for years they may take on rapid growth, the tumor being thus converted into an **adenosarcoma;** simultaneously the growth softens and becomes the seat of pain. After attaining a considerable size the tumor breaks down, with ulceration of the surface and hemorrhage. The branches of the seventh nerve become involved in the growth and facial paralysis occurs. The patient dies either from exhaustion from repeated hemorrhages or from septicemia.

Sarcoma of the Parotid Gland.—In all probability many of the growths in this region that were formerly described as sarcomas sprang from the lymphatic vessels as endotheliomas. Sarcomas appear as oval shaped, smooth, and elastic swellings. When composed of immature hyaline cartilage (chondrifying

sarcoma) they are of slow growth and seldom attain a large size. They may be of the larger and more rapidly growing spindle-celled variety, with some glandular and more or less chondral tissue present. The surrounding structures, including the skin, are rapidly involved, the facial nerve implicated, and the pharynx encroached upon. Myxomatous changes occur, with the formation of semifluctuating spaces. Dissemination is not common. Death takes place from interference with swallowing or from hemorrhage following ulceration of some large vessel in the neck.

Chondrifying sarcoma may also occur in the **submaxillary gland,** though less frequently than in the parotid. It may occur at all ages, is of slow growth, seldom attains a large size, and, as a rule, is found distinctly encapsulated.

Chondrifying sarcoma affecting the salivary glands may grow rapidly and destroy life in less than a year, or it may remain stationary for many years and then suddenly take on an exceedingly malignant character.

Both **adenoma** and **adenosarcoma** may arise from the glandular tissue independently of chondroma. The **differential diagnosis** between adenoma and sarcoma is sometimes difficult. Generally, however, sarcoma presents an evenly globular surface and adenoma a nodulated surface. Tumors removed from the parotid have shown sarcoma in one locality, adenoma in another, and myxoma or chondroma in still another. Cystic formations from obstruction of the gland ducts have also been present in the same gland. All parotid tumors generally grow from the middle portion of the gland just behind the ramus of the jaw and project forward. Those of the submaxillary gland are rarer, and may easily be mistaken for diseased lymphatic glands. They may be distinguished by palpation; those forming the mass of the lymphatic glands are usually separable, while tumors of the submaxillary gland proper form uniform masses.

The **treatment** of these tumors is extirpation. Small chondromas may frequently be "shelled" out without inflicting much injury on the gland. In case of large tumors, particularly in adenoma and sarcoma, extirpation of the entire gland is demanded. In the case of the parotid that portion which lies behind the auricle and passes deeply to the base of the skull is usually left behind because of the impossibility of its removal.

In **extirpation of the parotid** preliminary ligation of the common carotid is scarcely necessary, though extreme care must be exercised in order to avoid injury to both its external and its internal branches. If there is a suspicion that the growth involves one of these, a provisional ligature may be placed ready for tying in an emergency. The facial, temporal, and posterior auricular arteries may be ligated if injured. Special care is required in enucleating that portion of the growth which lies on the internal carotid artery and jugular vein. The branches of the facial nerve are almost invariably and unavoidably sacrificed in complete extirpation of the parotid. Permanent facial paralysis results.

Extirpation of the submaxillary gland is comparatively easy of performance. The facial artery is severed, but is easily secured.

Telangiectases of the parotid of congenital origin are sometimes observed in infants. They are usually associated with angiomatous conditions in the neighborhood. When of rapid growth and strongly pulsating, they demand extirpation.

Ranula.—This is a cystic tumor situated beneath the tongue. The growth

usually commences on one side of the frenum; as it increases in size it extends across to the opposite side. Rarely these tumors are observed commencing in the median line, in which case they have their origin in the glandula incisiva. In the case of large cysts the floor of the mouth and the under surface of the tongue are invaded; the former is crowded downward until the tumor appears beneath the chin, while the latter is crowded upward so as to cause mechanic interference with speech and mastication.

Ranula may have its origin in the duct of one of the glands of Bochdalek, or as a retention cyst arising from pressure of the inflammatory products of a diseased sublingual gland upon one or more of its secretory ducts. The cyst is usually unicellular, with viscid contents. The cyst growth may invade the mylohyoid muscle.

The cyst presents itself as a rounded tumor of a bluish-gray or a grayish-red color, occupying the space between the frenum and the inner margin of the lower jaw (Fig. 349). It may occur at any period of life and is sometimes congenital. It is usually slowly but steadily progressive in its growth; occasionally a small and perhaps unnoticed ranula may increase suddenly in size as a result of some irritation (**acute ranula**). Spontaneous rupture of the cyst wall sometimes occurs in the larger growths. This, like simple puncture, gives but temporary relief. The opening heals rapidly and the cyst cavity refills. As a rare circumstance infection and sloughing of the floor of the mouth may occur in ranula.

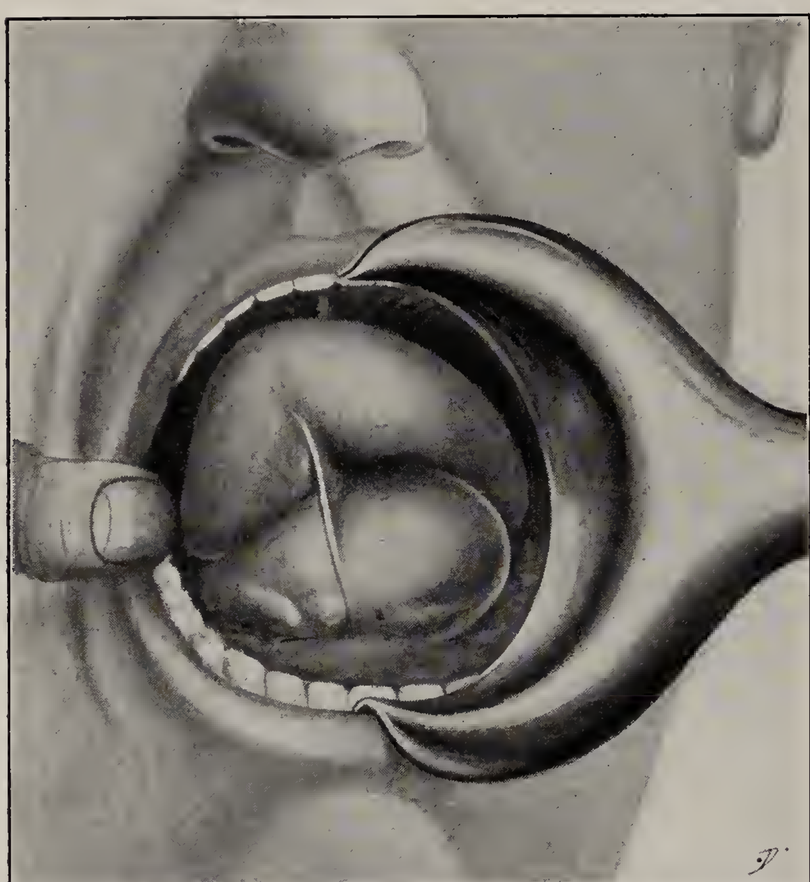


Fig. 349.—Ranula.

In the **differential diagnosis** the following are to be excluded: (1) Tumors of the sublingual gland itself. These are usually solid and of rare occurrence. (2) Lipomas of the floor of the mouth. These lack the color of ranula, and the greenish hue of the fatty tissue is usually to be distinguished beneath the attenuated mucous membrane. The sense of fluctuation obtained by palpating the ranula between the fingers is absent in the case of lipoma. (3) Sublingual dermoids. These are connected with either the lower jaw or the hyoid bone, but these connections are not usually to be made out except upon dissection. (4) Cystic dilatation of Wharton's duct. Here the duct is almost always occluded at its point of exit, while in ranula the duct can be demonstrated as pervious. The cylindriform swelling differs from the rounded up projection of a ranula. Cystic dilatation of the duct is usually accompanied by enlargement of the submaxillary salivary gland, and, when due to an inflammatory condition or the presence of a salivary calculus, by other and characteristic symptoms.

Treatment.—The cyst wall must be removed *in toto,* whenever possible. In the case of the larger growths the latter will be found to have followed the prolongations of the sublingual gland into the mylohyoid muscle (M o r e s t i n), in which case the gland will likewise require removal. In the small growths the cyst can usually be shelled out from the floor of the mouth by blunt dissection after incision of the mucous membrane. In case the cyst wall cannot be entirely removed, as much as possible should be excised, the cavity packed with gauze, and obliteration further favored by breaking up from time to time the adhesions which tend to form between the edges of the opening. Even after complete enucleation of the cyst it may be found that a swelling still exists in the submental region, due to the continued presence of a pathologic process in the gland itself underlying the original production of the ranula. Under these circumstances, and in the case of larger tumors as a rule, the more radical operation should be resorted to, and the ranula, sublingual gland, and Wharton's duct removed through an external incision made parallel to the inner edge of the lower jaw and the separated fibers of the mylohyoid muscle. If the mucous membrane in the floor of the mouth is adherent to the ranula, it should be removed as well.

Congenital dermoid cysts in the floor of the mouth are to be excised in the same manner as ranula. The operation is somewhat more difficult of performance, on account of the closer attachments of the sac wall to the adjacent tissues.

SECTION XV

SURGERY OF THE NECK

THE LARYNX, TRACHEA, AND HYOID BONE

Subcutaneous injuries of the larynx and trachea are rare in children and young adults, owing to the elasticity of the parts. Later in life the cartilaginous walls become more rigid and inelastic, owing to partial calcification and ossification, and hence give way more easily.

Fracture of the Thyroid Cartilages.—This is usually due to a grasp of the fist, the pressure being exercised in such a manner as to injure particularly the thyroid cartilages, either one of which, or both, may suffer. The line of fracture is generally oblique; the fragments are displaced temporarily and the glottic opening closed. When the grasp is relaxed, the fragments usually spring back in place and the glottis is free. When the mucous membrane is torn, **emphysema of the neck** may occur. The **diagnosis** rests on the occurrence of extravasation of blood in the neighborhood and extreme tenderness at the point of injury. Crepitation is not usually obtained, and when present it cannot be differentiated from the sounds that occur when an uninjured larynx is moved against the vertebral column. Laryngoscopic examination will reveal the presence of **submucous hemorrhage,** and, in case the line of separation approaches the anterior insertion of the vocal cords, the form of the glottis will be changed.

Life may be threatened by a steady increase of the submucous hemorrhage or hematoma; symptoms of obstructed breathing will give warning of the threatening danger. **Secondary edema** of the parts may also threaten life. The rapidity of the occurrence of either of these is sometimes so great as to destroy the patient before surgical help can be obtained, and for this reason it has been suggested to perform a **preventive tracheotomy** in all cases of fracture of the larynx, when the diagnosis is assured. In doubtful cases the patient should be carefully watched for obstructive symptoms. In the rare cases in which a fragment is permanently displaced, tracheotomy followed by **thyrotomy,** for the purpose of restoring the normal shape of the glottis by relieving the pressure, should be performed.

Injuries from burning or cauterization are rare, and when present are due to the inhalation of burning or corrosive fluids. Tracheotomy is also here indicated.

Fractures of the Hyoid Bone.—These are very rare. Disturbances of deglutition may result from the presence of a displaced cornua beneath the mucous membrane of the pharynx (Valsalva's dysphagia). The cornua may be replaced after incision or it may be extirpated.

Wounds of the Air-passages.—**Gunshot injuries** are infrequent. In case the blood does not find free exit through the wound, or is coughed out

as it flows into the larynx or trachea, suffocation may ensue. Immediate tracheotomy is indicated in this class of injuries.

Suicide wounds of the larynx and trachea are more common. The relative absence of danger to life in this class of injuries is well known. In these gaping incised wounds it is better to leave the wound to heal by granulation than to attempt complete suturing, on account of the dangers of emphysema of the neck. A compromise course which assists materially in shortening the healing process is to perform a low tracheotomy and suture the original wound at the angles. The wound may traverse the tissues so as to sever the attachments of the epiglottis and open the pharynx, in which case the patients must be fed by means of an esophageal tube. Wounds of the larynx and trachea may lead to **cicatricial stenosis** and require the permanent use of a tracheal cannula.

In **stab wounds** the weapon may penetrate the posterior wall of the upper air-passages, when the esophagus will also be opened. In **punctured wounds** emphysema is likely to occur and may be prevented or remedied by tracheotomy below the point of puncture. The emphysema soon disappears by resorption of the infiltrated air.

Rupture of the tracheal mucous membrane with infiltration of air into the connective tissue of the neck sometimes occurs from forcible shouting efforts. When this forms a saclike cavity on the side or in front of the trachea, it may simulate goiter.

Foreign Bodies in the Air-passages.—Irregular or spasmodic action of the muscles engaged in the act of swallowing is the usual cause of passage of portions of food, and particularly fluids, into the trachea. The sensitiveness of the glottis is such as to impel an act of coughing as soon as fluid comes in contact with that structure, which results in the removal of the latter. Suffocation may result from the passage of vomited matters as well as of artificial teeth in **surgical anesthesia.**

The space between the true vocal cords and the ventricular bands is a favorite place for the lodgment of **pointed** and **angular foreign bodies,** such as pins, fish-bones, etc. These may be removed by means of curved forceps with the aid of the laryngoscope. The further progress of the foreign body tends in the direction of the right bronchus, from the fact that the latter is almost a continuation of the trachea and has a larger lumen.

Small and smooth foreign bodies taken in the mouth by children at play sometimes pass into the larynx and produce suffocative symptoms. These shortly disappear on account of the forcing of the foreign body either upward into the ventricle of the larynx or downward into the trachea. In the former situation its presence may be easily recognized by means of the laryngoscope, and sometimes even in the latter situation, where, if not attached, it may be seen moving up and down with each act of respiration. **Auscultation over the trachea** will also give the physical signs of obstructed entrance and exit of air in case a foreign body with rough surface has lodged against the tracheal wall. In case the **foreign body has lodged in a bronchus,** the respiratory movements of that side of the chest are lessened, and the respiratory murmur found, on auscultation, to be notably weakened or absent altogether. The pectoral fremitus is also lessened. Interlobular emphysema, which may extend to the neck, has also been observed.

Treatment.—As soon as it is positively determined that the foreign body has passed beyond the glottis a tracheotomy must be performed. If the body is not coughed out through the tracheal opening, the latter will afford facilities for its subsequent dislodgment. If this fails, a Trendelenburg cannula may be introduced, the thyroid cartilages split (thyrotomy), and the foreign body removed. Or, the patient being guarded against further downward passage of the foreign body by the presence of the cannula, attempts may be made to remove it through the glottic opening with the aid of the laryngoscope.

If the lodgment is in one of the bronchial tubes, the case becomes greatly complicated. Here the tracheotomy wound will serve to facilitate the exploration, and may also serve to increase the ease of expulsion later on, should the foreign body become loosened by suppurative changes in the immediately adjoining tissues. If the foreign body chances to be metallic and hollow, as, for instance, a detached tracheal cannula, its presence and location may be determined by means of the **telephone probe.** Its removal will be greatly facilitated once its exact location is determined. With the tracheotomy wound located as low as possible, the foreign body may sometimes be reached with properly bent forceps. I once succeeded in thus locating and removing a tracheal cannula which had become loosened from its shield and had passed into the left primary bronchus. Finally, efforts at loosening and other measures failing, an attempt may be made to reach the site of the incarcerated foreign body, if in a primary bronchus, by means of resection of the chest wall behind. This operation was devised by me and carried out under my direction in the dead-house at St. Mary's Hospital by Dr. E. Arthur Parker, who was at that time my House Surgeon, on May 27, 1891. The experimental procedure demonstrated that the operation could be carried out without injury to important structures.* Gauze tamponade, without suture of the bronchus, tube drainage, and partial closure of the external wound meet the indications in the after-treatment.

Failure to remove the foreign body is usually followed by grave septic pneumonia in the respective portions of the lungs. Angular shaped or pointed objects may perforate a bronchus and cause **suppurative mediastinitis.** Perforation of the aorta or of the pulmonary artery may occur. The esophagus may be invaded; passage of food into the air-passages and fatal pleuropneumonia follow.

Laryngoscopy.—The requisites for an ordinary examination of the interior of the larynx are (1) a good light, the strong white light of a kerosene lamp answering the purpose admirably; (2) a perforated concave reflector three to four inches in diameter with a focal distance of from six to eight inches, and an apparatus to secure it to the head (Fig. 350); (3) laryngoscopic mirrors of various sizes (Fig. 351).

* At my request, Dr. Parker has furnished me with the following report of the experimental procedure from notes and a sketch made at the time: A foreign body (a cork from a medicine bottle) was introduced through a tracheotomy opening and forced into the left bronchus by means of a stout wire. The left arm was drawn forward to give additional space between the scapula and the spine. A "double door" incision was made to include the second, third, and fourth ribs, and the latter divided as near the spine as possible, and near the posterior border of the scapula. The included sections of ribs were removed and the pleura incised. A tenaculum was passed through the wall of the bronchus and into the cork, thus fixing the latter securely. An incision was then made over the cork in the long diameter of the bronchus, and the cork easily extracted.

The room is darkened and the patient seated with the lamp on a table and behind his left shoulder. The operator places the reflector on his head and

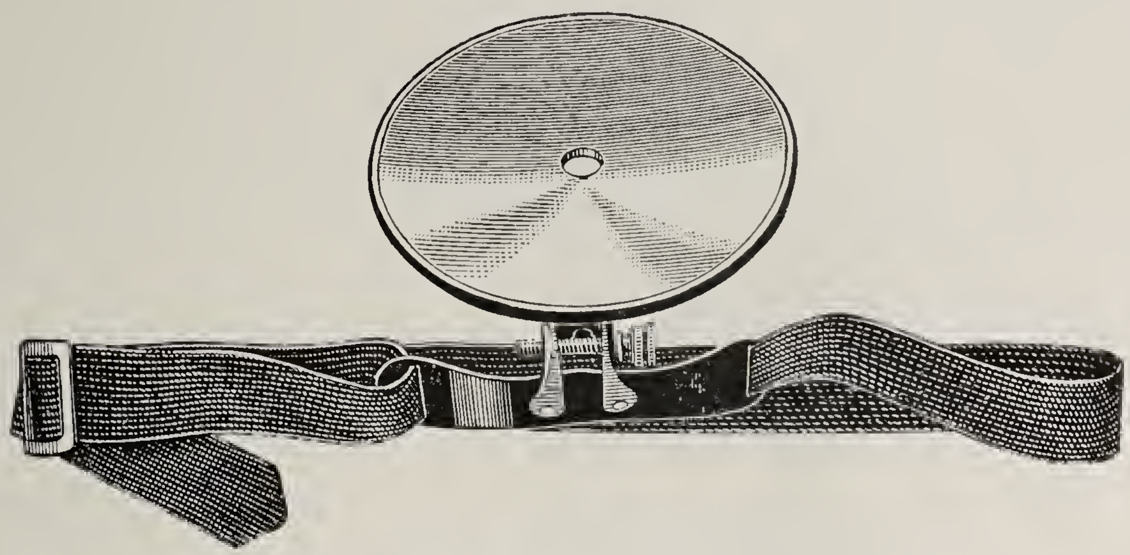


Fig. 350.—Laryngoscopic Head Band and Reflector.

adjusts the latter so that the perforation in its center, his own eye, and the back of the patient's larynx are in line (Fig. 352). In Collin's reflector

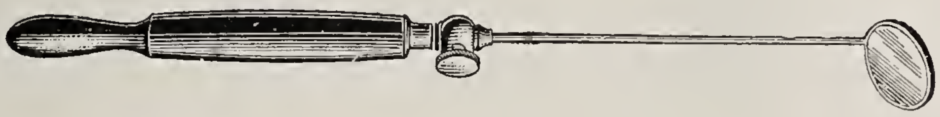


Fig. 351.—Laryngoscopic Mirror.

(Fig. 353) both eyes are employed. The surgeon draws the tongue forward by grasping its tip, slipping being prevented by the interposition of a single thick-

Fig. 352.—Laryngoscopic Examination.
The reflector and mirror in position.

ness of a coarse napkin or towel. The image mirror must be warmed before introduction to prevent condensation of moisture from the patient's breath on

its surface, and consequent blurring. The fauces may be advantageously sprayed with a 10 to 20 per cent solution of cocain to overcome troublesome irritability of the parts. The rays of light are caught on the reflector from the lamp behind the patient's shoulder and reflected on the surface of the mirror held over the glottic opening, in which is seen the *reversed* reflected image of the parts below (Fig. 354). When the patient makes such sounds as "ah" and "air" the vocal cords are readily seen in different positions, and upon deep and forced inspiratory efforts the tracheal rings, and under favorable circumstances the bifurcation of the trachea, are brought into view.

Fig. 353.—Collin's Electric Light Reflector.

Inflammatory Obstructions of the Larynx and Trachea.—Catarrhal inflammation in its severest form may lead to serious obstruction through serous infiltration of the submucous connective tissue, and demand tracheotomy. The mucous membrane covering the false vocal cords and aryepiglottic ligaments are most frequently the site of this submucous infiltration. Two roll-like masses result from edema of the long mucous folds of the latter, which upon inspiration are sucked in toward the central portion of the glottis and obstruct it. They can be felt by palpation from the mouth. There is no obstruction to expiration. **Edema of the glottis** may result from an extension of traumatic inflammatory edema of the pharyngeal mucous membrane. The **treatment** consists in scarification of the edematous tissue, and finally tracheotomy.

Fig. 354.—The Larynx as seen in the Laryngoscopic Mirror.
The illustration shows the parts larger than normal in order to bring out the details.

Diphtheritic inflammation produces stenosis of the larynx and trachea by both submucous infiltration and pseudomembranous deposit. The glottis itself, the narrowest portion of the air-passages, is the part which when encroached upon demands operative measures of relief. In these cases **intubation of the larynx** is frequently performed with benefit (O'Dwyer). The percentage of recoveries is about the same as in tracheotomy, with the added advantage that there is

no wound to become infected with the diphtheria (for operation of intubation, see page 604).

Tuberculous Laryngitis.—This usually commences at the interarytenoid plica or the insertion of the true vocal cords at the base of the arytenoid cartilages. Tuberculous ulcers with yellowish base are present; later on, other portions of the laryngeal mucous membrane may be attacked. Stenosis is rare from this cause alone, but the occurrence of inflammatory infiltration of the aryepiglottic folds, or a perichondritis, may produce obstruction. If the arytenoid cartilages are involved there will be pain on deglutition.

Syphilitic Laryngitis.—This occurs as a gummatous infiltration and perichondritis, with or without ulceration. In syphilitic perichondritis the cricoid especially is attacked.

Variolous and typhoid laryngitis is a metastatic inflammation which produces ulcerative destruction of the mucous membrane. In the first named the dangers of obstruction are due in the beginning to inflammatory swelling of the mucous membrane and later to perichondritis. In typhoid ulceration obstruction rarely occurs until later, or during convalescence, when cicatricial contraction may follow the healing of the ulcer; or the obstruction may be due to perichondritis.

Inflammatory thickening of the vocal cords (**chorditis vocalis inferior hypertrophica**), due to chronic catarrhal inflammation of the inferior or true vocal cords, may produce a stenosis sufficient to necessitate tracheotomy.

Tracheotomy.—The term **laryngotomy** is applied when an opening is made from without into the larynx; **laryngotracheotomy** when the opening is made in the cricoid cartilage and the adjoining tracheal rings; **tracheotomy** when the trachea is opened. Generally speaking, however, these are all included under the latter term. The operation is indicated by the presence of a narrowing of the normal lumen of the tube sufficient to interfere with respiration and endanger life. It is also applied as a **preliminary operation** in laryngotomy, laryngectomy, and other operations about the upper air-passages and pharyngeal and oral cavities. Among the acute obstructions requiring the operation as an emergency procedure may be mentioned (1) croup and diphtheria; (2) inflammatory affections and edema of the larynx; (3) foreign bodies in the larynx; (4) bilateral abductor paralysis; (5) spasm of the larynx (occasionally in children, rarely in adults). It is also employed in syphilitic and tuberculous disease of the larynx to give the parts rest; in tumors of the larynx and for the removal of foreign bodies from the trachea and bronchial tubes.

In croup and diphtheria, and in abductor paralysis, the mistake of delaying the operation too long should not be made. To be of benefit it should be performed while there is yet hope of saving the patient's life, and not postponed until euthanasia constitutes the only indication in the case.

The **anesthetic** employed should be chloroform whenever practicable. This is usually safe in the case of children; ether is very irritating to the mucous membrane of the air-passages. In adults **cocain** (4 per cent solution) may be injected under the skin at the site of the cutaneous incision, the local anesthesia thus obtained lasting for from ten to twelve minutes (Bosworth), and being efficient for all the structures except the mucous membrane. Finally, in the case of very young children, when struggling may be prevented by wrapping the child in a blanket, and of older children who are

practically already anesthetized by carbon dioxid poisoning, anesthesia may be omitted altogether.

Choice of Operation.—Under circumstances of extreme emergency the trachea may be opened by a single cut, or **rapid tracheotomy** (Dunham), without reference to the presence of large veins or the thyroid isthmus. The trachea and larynx are steadied laterally by the thumb and finger of the left hand, or a large tenaculum hooked deeply and firmly into the cricoid or cricothyroid membrane. Though a plexus of veins lies on each side of the line of incision, yet not infrequently a large vein or two, increased in size by obstructed breathing, crosses the trachea. The only normal artery likely to be met with is the cricothyroid, and this is placed so high (at the lower border of the thyroid cartilage) as to be practically out of the way in almost all of the operations of choice. An occasional arterial abnormality, the **arteria thyroidea ima,** is met with; it rises from the arch of the aorta and passes directly upward in the middle line to the lower border of the thyroid. In a low or **infrathyroid tracheotomy** the innominate artery may be endangered. In young children the thymus gland may be an obstacle. In spite of these latter objections and of the fact that the trachea in children is more deeply placed and smaller in diphtheria cases, in which it is desirable to place the tube as far away as possible from the pseudomembranous exudation, as well as in cases of malignant disease in which the cannula must be permanently worn, the low operation should be performed. Where the isthmus can be severed between two ligatures, the tube may be placed at its site. In an emergency requiring rapid tracheotomy, and under circumstances which demand prompt interference on account of threatened suffocation, the most superficial portion of the tube is chosen (**laryngotracheotomy**).

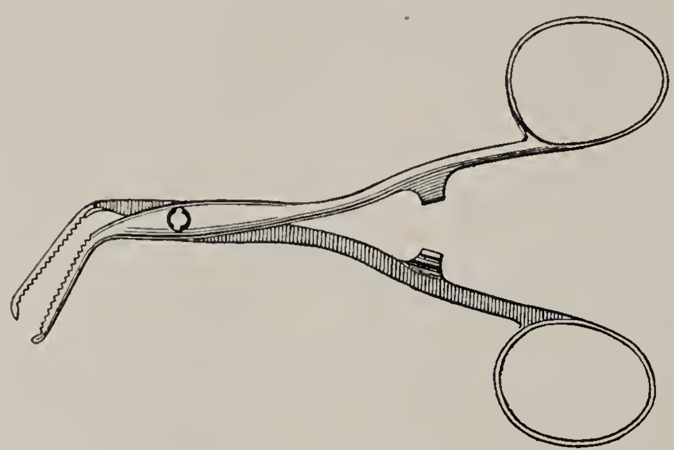


Fig. 355.—French's Combined Hemostatic Forceps and Retractor.

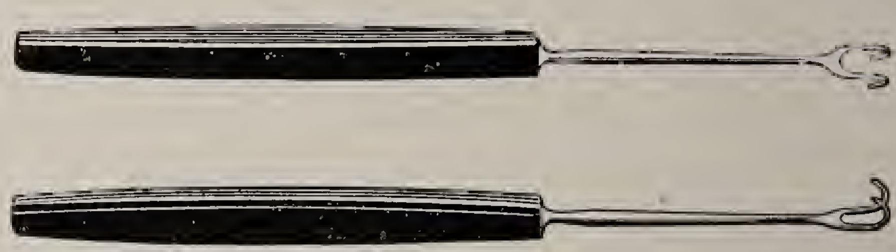


Fig. 356.—Pilcher's Retractors.

The Operation.—The patient, if a child, is wrapped in a blanket which is snugly pinned so as to confine the arms at the lateral portions of the body; they should not be crossed over the chest. He is placed on the table so that a good light may be obtained. The parts to be operated on are brought into prominence by a hard pillow made by wrapping a wine bottle in a towel, or some similar device. The instruments required are a scalpel, half a dozen artery clamps (French's clamps are the most convenient), four small retractors (Fig. 356) (two sharp and two blunt), two pairs of thumb forceps, a grooved director, a strong and well curved tenaculum for fixing the trachea (Fig. 357), curved and straight blunt pointed scissors, an aneurism needle, and curved and

straight needles. Silk and catgut are also needed for suture and ligature purposes. An assortment of tubes must be at hand. The one best adapted to the case is prepared, with tapes attached, and placed conveniently near. The other instruments are placed in the order in which they are to be used. A median incision is made from the lower edge of the cricoid cartilage downward for from an inch and a half to two inches, including the skin and superficial fascia; the anterior jugular veins, one on each side of the larynx and trachea, pass downward and are joined by a transverse trunk just above the sternum. The lateral ribbon-shaped muscles (the cricothyroid above and the sternothyroid below) are separated by the handle of the scalpel and drawn apart by small blunt retractors, so that the deep fascia is brought into view. The latter divides into two layers to inclose the isthmus of the thyroid, which is recognized by its pinkish red appearance, resting on the second and third rings of the trachea. The deep fascia is carefully nicked just below the lower border of the isthmus and divided on a grooved director, the incision baring the rings of the trachea with some loose connective tissue in front. A stout tenaculum is now inserted, point upward, at the lower border of the isthmus into the trachea to steady the latter while it is being incised. Whenever possible, a loop of strong silk is passed through each edge of the tracheal incision for purposes of retraction. As large a tube as can be passed without crowding should be used.

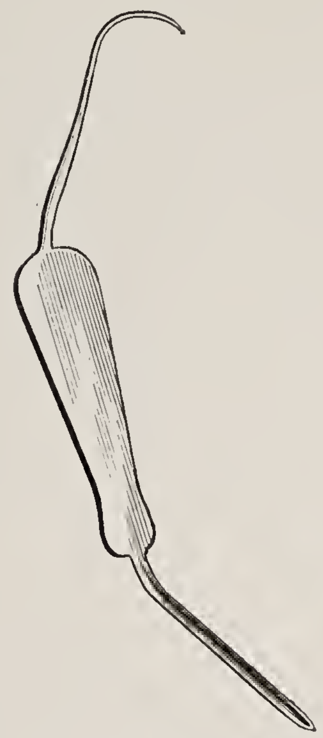


Fig. 357.—Combined Grooved Director and Tenaculum.

Various **tracheotomy tubes** have been devised; the best is that known as the Cohen model (Fig. 358). It is flattened from side to side, so that its introduction is facilitated and the tendency of the posterior wall to bulge forward, as a consequence of wide separation of the edges of the divided tenaculum rings, is lessened. A pilot trocar aids in the introduction in emergency cases and during the after-treatment, but if the loops of thread above mentioned can be placed in position and retained, this, as well as tracheal dilators, can be dispensed with. The wound is closed by interrupted sutures, except at the point where the tube emerges, and dressed with iodoform gauze.

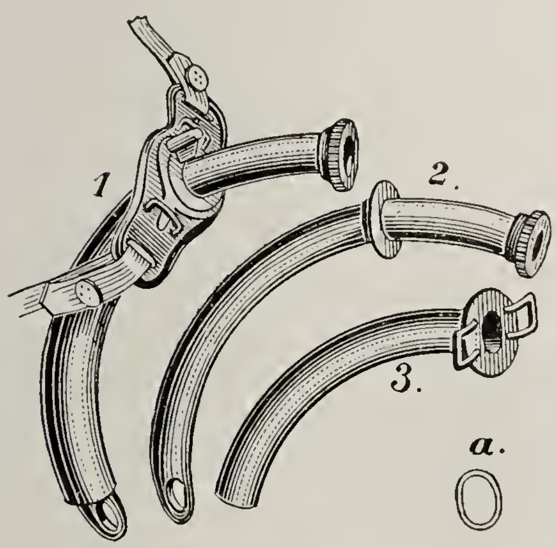


Fig. 358.—Cohen's Tracheotomy Tubes.

1, Outside tube and obturator; 2, obturator; 3, inside tube; *a*, cross-section of the tube.

The tube is secured in place by tapes about the neck and covered by a number of thicknesses of gauze saturated with a sterilized normal salt solution. The atmosphere of the room is kept moist and at a temperature of at least 80° F. In croup and diphtheria cases a watchful care is to be exercised to prevent the tube from becoming blocked by pieces of false membrane. The inner tube is to be removed and cleansed from time to time. In an emergency both tubes are to

be removed at once and the patency of the opening maintained by the loops of thread. The tube should be dispensed with at the very earliest possible moment.

In **suprathyroid tracheotomy** the incision commences opposite the middle of the thyroid cartilage. The isthmus is loosened by the handle of the scalpel and crowded downward, where it is held by a small blunt retractor while the trachea is steadied by a tenaculum and the first two or three rings incised. In **laryngo-tracheotomy** the incision is carried upward instead of downward, dividing the cricoid cartilage and the cricothyroid membrane. This operation is rarely required except for exploratory purposes, and in case the isthmus is placed abnormally high and is very broad. **Cricothyroid laryngotomy** is an exceedingly simple operation and hence is sometimes employed when the emergency of the case demands a speedy opening of the windpipe. The incision is confined to the cricothyroid membrane. A tube introduced at this point is not well tolerated and but a limited space is afforded for its introduction, so that only a small tube can be used.

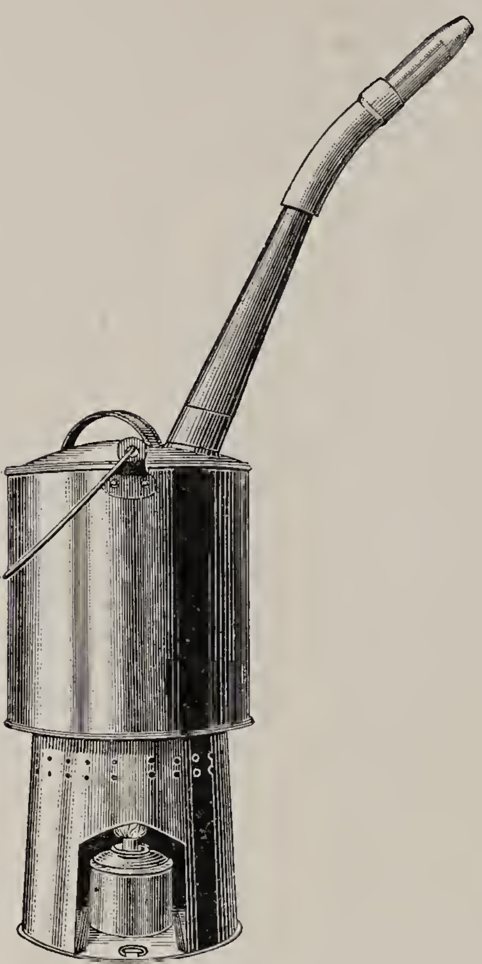


Fig. 359.—Croup Kettle.

The After Course and Treatment in Tracheotomy Cases.—When the operation is performed for the relief of stenosis due to diphtheritic conditions of the larynx or trachea, in addition to meeting the immediate indications for the prevention of suffocation and removing whatever diphtheritic membrane may be detached or detachable, the procedure permits the application of proper local remedies to the diseased area. The tracheal wound also gives ready exit to loosened portions of pseudomembrane, which are propelled upward by acts of coughing. This loosening is hastened by **inhalations of steam.** The stream of steam from a croup kettle (Fig. 359) or from a common teakettle with a tube extension on the spout, is directed so as to be inhaled through the cannula. The addition of glycerin to the boiling water is said to hasten the separation of the diphtheritic deposit by producing a serous transudation of the mucous membrane (P. Voigt). The entire effort must be directed toward preventing the drying of the secretions of the larynx and trachea.

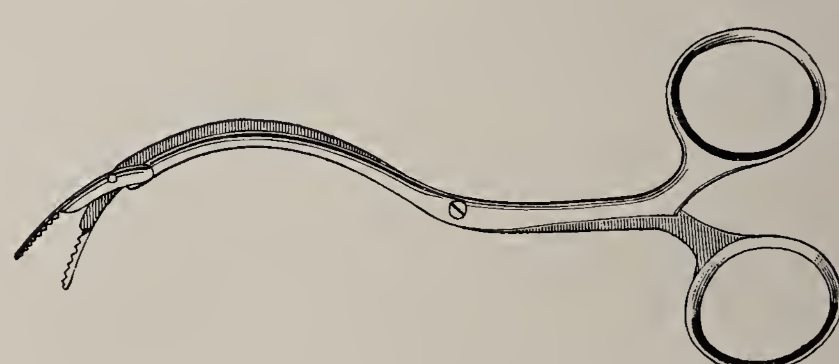


Fig. 360.—Intracannular Alligator Forceps.

By the flapping noise the practised ear will at once detect when a portion of diphtheritic membrane is loosened but cannot escape. Under these circumstances the curved intracannular forceps (Fig. 360), which should always be at hand, are to be used. They are passed through the cannula, the jaws opened,

and while a coughing effort is made the jaws are closed and the instrument withdrawn. This may be frequently repeated, but if it is found that the loose piece is not caught after several trials, the entire cannula should be removed, when the mass will almost immediately follow. If not, the forceps should be carried through the wound to the interior and further efforts made.

The inner tube may be removed occasionally for purposes of cleansing. During the intervals a compress made of a number of thicknesses of gauze, and moistened with a sterilized salt solution, should be kept over the cannula.

The Treatment of the Wound.—Complete aseptic régime cannot be maintained in the treatment of the wound. A piece of iodoform gauze may be placed between the shield of the cannula and the wound surfaces, and changed frequently. In nondiphtheritic cases the wound usually heals without complication. **Infection of the wound** is very likely to follow in cases of diphtheritic inflammation of the trachea. The infected wound surface is to be treated with gauze compresses wrung out of a 5 per cent carbolic acid solution or disinfected with a 5 or 10 per cent chlorid of zinc solution. Phlegmonous inflammation of the connective tissue of the neck may occur. This is an exceedingly serious complication and is to be met by the frequent application of compresses dipped in solutions of corrosive sublimate, 1 : 2000 in 50 per cent alcohol, or the carbolic acid and opium lotion (see page 160).

Diphtheritic ulceration of the anterior tracheal wall may arise in consequence of severe diphtheria of the mucous membrane and of the wound. A tracheal stenosis may arise from this cause, necessitating in very rare instances a second tracheotomy. Or, the tracheal wound may fail to close and a subsequent plastic procedure become necessary.

Diphtheritic Paralysis.—Motor paralysis of the muscles of the palate and sensory paralysis of the nerve-fibers at the entrance of the larynx permit fluids to pass through the glottic opening and out of the tracheal wound. The diet therefore should be restricted to sterilized milk. Should the patient's nutrition suffer because of inability to swallow sufficient milk, the stomach tube should be employed or nutrient enemas administered.

Paralysis of the vocal cords sometimes remains after severe laryngeal diphtheria, with resulting aphonia. Spontaneous recovery usually takes place, as in other paralyses of diphtheritic origin. Electric applications to the muscular apparatus of the larynx are useful in obstinate cases.

Ulceration of the trachea from improperly curved tubes occurs in a certain proportion of cases. The resulting hemorrhage is sometimes sufficient to cause obstructed breathing. The introduction of a tampon cannula (Trendelenburg's, page 535) will arrest the bleeding. The preventive treatment consists in removal of the cannula as early as possible.

Granulomas sometimes form at the edges of the tracheal wound and in the tube track. When within the trachea, they mark the site of pressure ulcers. When in the latter location, they may cause suffocative attacks after the removal of the tube and the closure of the external wound, by being drawn in with the inspired air. The granulomas may be destroyed by nitrate of silver or chromic acid, the cannula being replaced until smooth cicatrization of the surfaces has been secured.

Attacks of suffocation are sometimes observed after removal of the tube, when no discoverable cause for these is present. They are due to psychic

causes and paralysis from long inactivity of the posterior cricoarytenoid muscles. The patient should be encouraged to make long and forcible inspiratory efforts. Electric treatment is also useful.

Permanent Removal of the Tube.—In diphtheria cases the cannula can generally be dispensed with after the fifth day. If, upon dispensing with the tube for a short time, the obstructed breathing recurs, the tube should be replaced and another trial made on the following day. A compress placed over the wound for a few seconds while the patient is directed to make forced inspiratory and expiratory efforts will assist in restoring the function of the muscular apparatus of the glottis, when the difficulty is due to inactivity of this. When tracheotomy is performed for **foreign bodies,** it may not be necessary to employ a cannula; at the most this will be required only for a day or two after the removal of the foreign body. In **stenosis from tumors** or **cicatricial bands,** unless the cause can be removed by other operative procedures, the tube must be worn for life. Under these circumstances the track of the tube becomes covered with mucous membrane from within outward, and by a layer of epidermis from without inward, the two layers meeting. After **preliminary tracheotomy** the cannula can be removed as soon as the operation is over, as a rule, or it may be left in place for a short time to prevent blood and wound secretions from entering the air-passages.

In acute cases the wound heals rapidly after removal of the tube. In those who have worn a tube for a long time a minute fistulous opening may remain after its removal.

Persons who are compelled to wear a tracheal cannula permanently should be taught how to remove and cleanse the tube. It is better for these patients to wear a hard vulcanized rubber tube of solid construction to avoid accidents arising from corrosion of the metal tube at the point where it is soldered to the shield.

Intubation of the Larynx (O'Dwyer).—This operation has largely replaced tracheotomy in cases of diphtheria. It is also employed in stenosis of the larynx from causes other than malignant disease. As in the case of tracheotomy, it should be performed early in order that the greatest benefit may be derived from its use. It has the disadvantage of requiring special instruments for its performance, whereas in tracheotomy the urgently demanded relief can be obtained by means of instruments usually at hand. This disadvantage is offset, however, by the fact that it entails neither loss of blood nor shock, and can be speedily performed.

The instruments as ordinarily supplied are (1) a set of tubes with obturators, adapted to the ages between one and twelve years; (2) a metal gage to aid in the selection of the proper tube; (3) a mouth-gag; (4) a tube introducer; (5) a tube extractor (Fig. 361).

Operation.—The child is held upright on the lap of an attendant, with its head resting on the latter's left shoulder, so that the body, head, and neck are in a straight line. The arms are held securely against the patient's body. The mouth-gag is inserted in the left angle of the mouth as far back as possible between the teeth, and the latter forced apart as far as possible. The proper sized tube is attached to the introducer by its obturator, a piece of thread attached to the tube by passing it through a hole provided for the purpose, and

the thread wound around the little finger of the right hand of the operator. This thread is to facilitate the immediate withdrawal of the tube should it become improperly lodged. The introducer is grasped in the right hand while the tip of the left index-finger is passed to the epiglottis, identifying it. The latter is raised so as to uncover the glottic opening, and the tube is passed, guarded by the index-finger. As the tube glides over the now vertically placed epiglottis and enters the glottis, the guiding index-finger is shifted posteriorly toward the pharyngeal wall, where it prevents the tube from slipping into the esophagus. The proper position of the tube being assured, it is at once driven home and at the same time released from its obturator and the introducer by

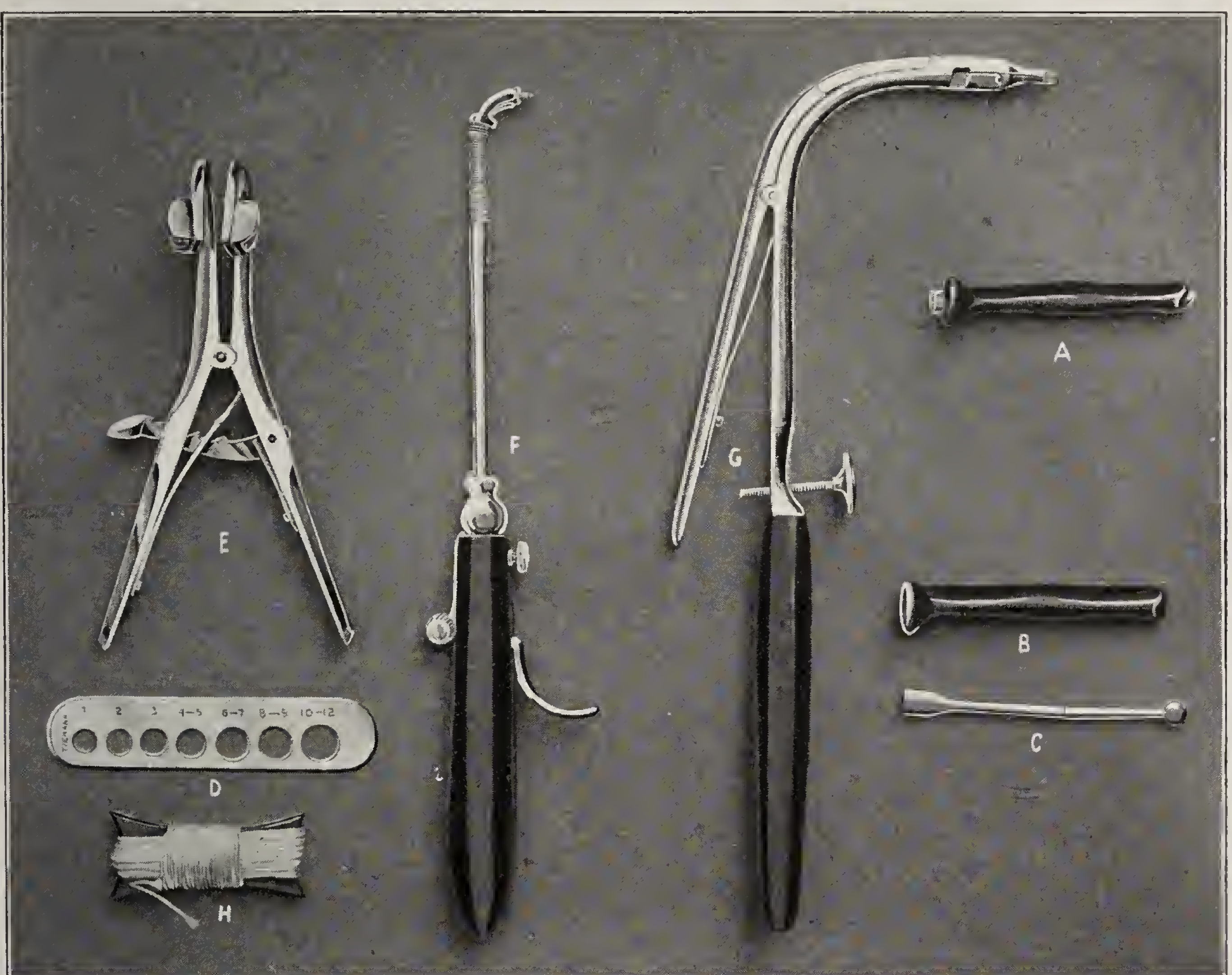


Fig. 361.—O'Dwyer's Intubation Instruments.
A, Tube with obturator; B, tube; C, obturator; D, metal gage; E, mouth-gag; F, introducer; G extractor; H, silk cord.

pushing forward the slide on the latter with the thumb of the right hand. The introducer with the attached obturator is now withdrawn. The left index-finger then identifies the tube in position, and, if not placed well down in the glottic opening, it is pressed home by the same finger. The gag is then removed. If the breathing is relieved, the gag is again introduced and the tube steadied with the finger as before, while the thread is withdrawn. In case the tube is expelled by the subsequent coughing efforts, a larger one should be introduced.

The **removal of the tube,** which is usually safe after from three to nine days, is effected by a maneuver similar to that by which it was introduced. The child is held in the same manner, the gag introduced, the top of the tube identified by the left index-finger, and the extractor introduced. The blades of the

latter are released by a device on the shank worked by the thumb of the hand which grasps the instrument as the point of the latter passes into the lumen of the tube. The spread-out blades of the extractor engage the tube and the latter is withdrawn.

The following **precautions** must be observed: (1) The operator should become thoroughly familiar with the mechanism of the instruments, and, if possible, practise the operation upon the cadaver; (2) the finger should not be held too long over the glottis lest suffocation take place.

The **dangers** of the operation are the following: (1) Membrane may be pushed ahead of the tube and produce obstruction. This will necessitate withdrawing the tube immediately and waiting until the loosened membrane has been expelled before reintroducing it. (2) Failure to remove the thread may lead to the swallowing of the latter, followed by the tube itself. Should this occur, another tube must be introduced at once. The swallowed tube will be expelled with the bowel movements.

Tumors of the Larynx and Trachea.—Papilloma.—This is a connective-tissue new formation (fibrosarcoma) with a broad base and fissured surface. The smaller growths occur isolated or in groups at the free edge of the anterior commissure of the vocal cords. Large growths occupy by preference the aryepiglottic ligaments and occasionally the posterior surface of the epiglottis. These occur generally in children. **Pediculated fibromas** originate from the free edge or lower surface of the vocal cords. The first named usually give rise to progressive aphonia at the commencement; later on they may increase in size sufficiently to cause dyspnea. The pediculated fibromas may give rise to suffocation early in their history.

Sarcoma of the larynx is rare, and when it does occur it springs from the lateral wall. **Myxoma, angioma,** and **adenoma** of the larynx are very rare. **Enchondroma** of the thyroid and cricoid cartilages is also very rare. Large intralaryngeal growths of benign origin are best dealt with by laryngotomy.

Tumors of the trachea are exceedingly rare, except the granuloma due to the use of a tracheal cannula. Sarcoma and submucous fibrosarcoma have been observed.

Cancer of the Larynx.—This is the most important of the malignant growths. It occurs both as a primary affection and as an extension of disease from carcinoma of the tongue, fauces, and esophagus. It is essentially a disease of adult life. It may arise in the mucous membrane of the ventricles, vocal cords, or ventricular bands (**intrinsic cancer**); in the aryepiglottic folds, or the covering of the arytenoids, or the interarytenoid fold (**extrinsic cancer**). The first named is papillomatous in character, almost always occurring as a warty growth. Lymphatic glandular infection and dissemination are uncommon. On the other hand, in the extrinsic variety the disease extends rapidly and infects the lymph-glands promptly. The clinical importance of the distinction is further emphasized by the fact that implication of the surrounding parts occurs far more frequently in the extrinsic than in the intrinsic variety, and operative interference (excision of the corresponding half of the larynx, or thyrotomy and thorough removal of the soft tissues) gives far better results in the intrinsic form of the disease than in the extrinsic. Indeed, in the majority of cases of the latter, as well as in those cases of the former too far advanced for thyrotomy, the only hope of saving the patient from death from

suffocation resides in tracheotomy. The slight tendency to involvement of the thyroid cartilage in the intrinsic form of the disease, and the low mortality following thyrotomy as compared with that following complete or even partial laryngotomy, have given a hopeful impetus to the effort to diagnose the disease early by the removal with the intralaryngeal forceps and the microscopic examination of portions of all suspicious growths in the larynx occurring in middle-aged adults.

The laryngoscope is to be employed in the **diagnosis** of tumors of the larynx. The small benign growths are best removed by **intralaryngeal operations** at the hands of skilled laryngologists. In malignant disease, the diagnosis being established early by microscopic examination of portions removed by the laryngologist, either **thyrotomy** or **partial extirpation** of the **larynx** is indicated (*vide supra*). If the growth has extended to the pharynx or upper portion of the esophagus, operation is not admissible.

Laryngeal Stenosis of Cicatricial Origin.—Ulcerative processes, of which that arising from **syphilitic laryngitis** is the most common, are the most frequent causes of this condition. Next in frequency is **typhoid ulceration.** The causes which produce primary inflammatory stenosis rarely produce cicatricial stenosis.

Traumatism may cause stenosis of the larynx, such, for instance, as follows ulcerative or suppurative conditions due to the pressure of angular foreign bodies, or wounds from pointed foreign bodies. Gaping transverse incised wounds which heal by the formation of dense cicatricial tissue, and fractures of the larynx in which the fragments remain unreduced, will also give rise to stenosis.

The **diagnosis** of stenosis is based on the history of the case, the peculiar whistling noise accompanying the respiratory movements, and the dyspnea. Laryngoscopic examination will reveal the location and degree of the affection.

The **treatment** consists in attempts at dilatation through the glottic opening, or a tracheotomy wound if this operation is demanded, preliminary incision of the cicatricial tissue being practised when necessary. The dilatation is best carried on by the use of intubation tubes, progressively increasing sizes of these being introduced and worn. Recurrence is the rule, however, both in dilatation and in **resection of the larynx,** cicatricial tissue taking the place of that removed in the latter. In cases otherwise irremediable an intubation tube if possible, or, this being impracticable, a tracheal cannula must be permanently worn. To improve the speech a separate tube which passes upward toward the glottis and is attached to the tracheal cannula is to be employed (Richet). The instrument resembles the artificial larynx of Gussenbauer. This device is also to be employed in cases in which collapse of the laryngeal framework follows removal of diseased cartilages.

Laryngotomy.—In former times laryngotomy was frequently resorted to for the removal of foreign bodies lodged above the true vocal cords, in cases where the symptoms were not sufficiently urgent to demand tracheotomy. The perfection of intralaryngeal methods and the introduction of cocain anesthesia have restricted the indications for this operation to cases in which intralaryngeal methods of extraction have failed, and to cases of fracture of the larynx in which fragments of cartilage project into the lumen. The complete separation of the two halves of the larynx after total

laryngotomy, or **laryngofissure,** as it is sometimes called, leads to changes in the voice, the two portions failing to resume their exact original relative positions.

Thyrotomy has replaced, to a great extent, laryngotomy. It is indicated in cases of impacted foreign bodies in the glottis and benign tumors not amenable to intralaryngeal methods of removal. Preliminary tracheotomy and the introduction of a tampon cannula are necessary. If possible, this should be done three or four weeks beforehand.

Operation.—An incision is made from the pomum Adami to the cricothyroid membrane. The point of the knife enters the cavity of the larynx through the membrane and separates the latter from the thyroid cartilage by a transverse cut in both directions. This avoids injury to the cricoid artery. The sternothyroid muscles are separated; the cricothyroid of each side is to be preserved as far as possible. One blade of heavy blunt scissors is introduced into the cavity of the larynx between the vocal cords, and the thyroid cartilage split along the median line from below upward and from within outward. Where the cartilage is ossified, bone cutting forceps must be used. If the cartilage is sufficiently flexible, in order to secure accurate reposition and avoid changes in the voice it is advantageous to preserve the uppermost edge intact (Coates). The cricoid preserves the relation of the two halves sufficiently well, as a rule, however. After complete separation, if more room is necessary, the thyrohyoid ligament is to be divided transversely, after which the thyroid cartilage may be widely separated by means of retractors. A small opening will be sufficient for the removal of a foreign body, but more space will be required for the extirpation of a tumor.

In replacing the parts care must be exercised lest the vocal cord of one side is placed on a lower level than the other. The cartilage, as well as the overlying parts, must be accurately sutured; a tracheal cannula is to be left in place for a few days to prevent emphysema of the neck from air forced between the sutures into the connective tissue.

Extirpation of the Larynx (Laryngectomy).—This operation is sometimes performed for malignant disease of the larynx. The operation is to be preceded by low tracheotomy, performed, if possible, two or three weeks beforehand, and the introduction of the tampon cannula at the time of the operation.

Operation.—An incision is made from the hyoid bone to the edge of the cricoid. From each extremity of this incision a transverse cut is made in the direction of the anterior edge of each sternomastoid muscle. The two quadrangular flaps of skin are turned back and the separation of the larynx effected from below upward (Billroth) as follows: The trachea is separated from the cricoid cartilage by a transverse cut, and the larynx drawn forcibly upward and forward by a strong tenaculum. This gives access to the posterior wall of the larynx, from which the esophagus is to be separated. The separation is continued posteriorly and laterally from below upward, the growth, which usually occupies the region of the arytenoid cartilages, separating with the larynx. If it invades the pharyngeal wall, this is to be removed as far as necessary. In separating the larynx from the thyroid body the knife must be kept close to the former, in order to avoid injury to the superior thyroid artery as it passes from above to the inner edge of the lobe. Finally, the

larynx is separated from its attachments to the tongue. In small growths the separation may be made at the thyrohyoid membrane, the epiglottis remaining intact. In more extensive growths the epiglottis also must be removed, in which case the final separation takes place at the deep muscles of the tongue. It may also be necessary, if such a radical procedure is indicated, to remove portions of the underlying muscles (sternohyoid, sternothyroid, and thyrohyoid). Here both the superior and the inferior thyroid artery must be divided and ligated. The hemorrhage may be troublesome if it becomes necessary to remove portions of the thyroid gland; the ascending palatine artery may be injured in the removal of portions of the pharyngeal wall.

Partial lateral excision of the larynx, one half being preserved (Billroth, Max Schede, Hahn), has been performed when the disease has been apparently limited to one side. The thyroid cartilage is separated in the median line, as in thyrotomy, and one lateral half of the larynx removed from below upward. The epiglottis can usually be preserved.

Partial Laryngectomy (Cohen).—The posterior third of the thyroid cartilage has been found remarkably free from disease in epithelial carcinoma. Inasmuch as this portion of the cartilaginous framework of the glottis serves for the attachment of certain muscles which are of importance in the act of swallowing (inferior constrictor, stylopharyngeus, and palatopharyngeus) the importance of the preservation of this is manifest. The steps of the operation are carried out as in total extirpation, except that the thyroid cartilage is split each side of the median line and along the line of attachment of the inferior constrictor muscle to the cartilage. The entire larynx with the exception of this portion of thyroid cartilage, including the interior of the glottis itself, comes away in one piece. In the first case of epithelial carcinoma of the larynx operated on after the method proposed by Prof. Cohen, in my service at the Methodist Episcopal Hospital, the patient lived twenty-seven months, finally dying of the recurrence of the disease in the cicatricial tissue and skin surface.

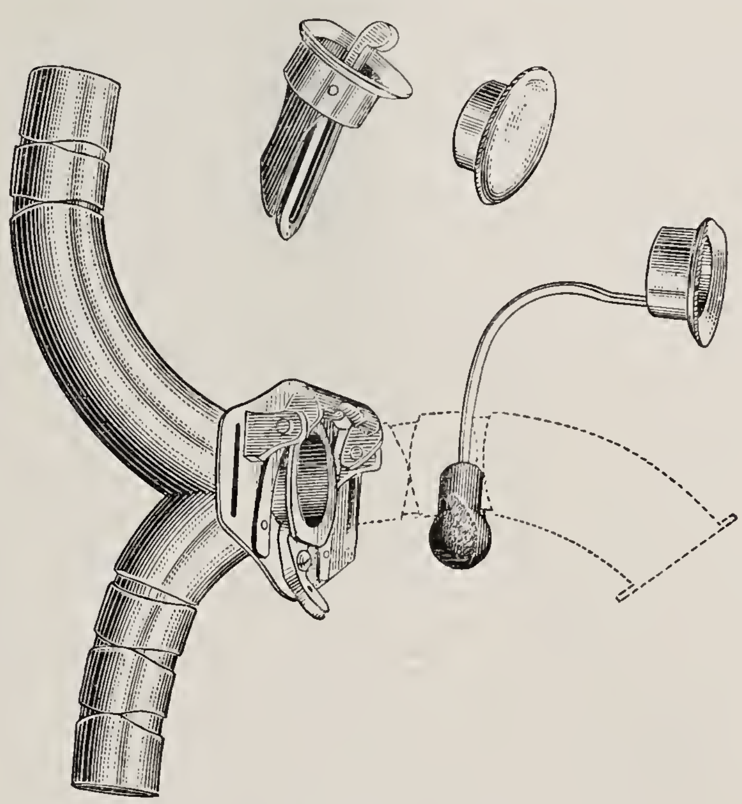


Fig. 362.—Park's Modification of Gussenbauer's Artificial Larynx.

After-treatment.—The parts about an ordinary tracheotomy tube, if this is used in the after-treatment, are to be packed carefully with iodoform gauze. Or the tampon cannula may be worn. The trachea is to be protected against the entrance of wound secretions, in order to avoid septic bronchitis and pneumonia. Feeding is carried on in the beginning by means of the stomach tube. The wound is partially sutured above and the cavity from which the larynx has been removed packed with oxid of zinc or plain sterile gauze. Daily repacking and antiseptic irrigation are necessary. The wound

gradually retracts to a narrow opening above the tracheotomy tube. The latter is to be eventually transferred to this and the low tracheotomy wound permitted to heal. Before final contraction of the parts above the stump of the trachea occurs an artificial larynx is to be fitted (Gussenbauer, Fig. 362). The speech thus obtained is such as can be easily understood, though it is absolutely monotone. The vocalizing portion of the apparatus obstructs the breathing as soon as mucus collects upon it, and patients must be taught to remove it for purposes of cleansing. Without it, conversation can be carried on in a whisper, the consonant sounds being formed by the closing of the external opening and the forcing of the air through the pharyngeal, oral, and nasal cavities.

When eating, the patient replaces the vocalizing apparatus by an obturator which closes the upper or chimney portion of the artificial larynx (P. Bruns) and prevents food from being forced into the tube. He soon learns to substitute the base of the tongue for the removed epiglottis and dispenses with the obturator entirely.

When one lateral half of the larynx is removed, the use of an artificial larynx may not be necessary (Max Schede).

Mortality.—The immediate mortality following total laryngectomy is about 40 per cent. Of those who recover from the operation itself, about 50 per cent die of septic bronchitis or pneumonia during the first two or three weeks. Recurrence takes place at periods varying from nine months upward (Hahn). One case, when last heard from, had gone four years without recurrence. Recurrences are regionary, as a rule. The mortality following extirpation for **sarcoma** is somewhat less, and recurrence is less likely to occur.

The immediate mortality following partial (one-sided) extirpation is less than that following total laryngectomy. The average length of time before recurrence takes place in both partial excision and total excision varies with the extent of the disease and the ability of the operator to extend the extirpation of surrounding tissues beyond the limits of the growth. As in malignant disease elsewhere, early interference is always to be strongly urged.

THE THYROID GLAND

Injuries of the thyroid gland occur almost exclusively in connection with self-inflicted suicidal wounds. The injury inflicted on other parts is usually more important than that of the thyroid, though the hemorrhage may be abundant, particularly in the somewhat rare instances in which the lateral lobes are reached by the incision and the thyroid arteries divided. The **isthmus** may be injured in the operation of tracheotomy, and in diphtheritic cases may become the site of infection.

Thyroiditis, or non-traumatic inflammation of thyroid tissue, is very rare in healthy glands. It usually ends in formation of abscess. Pyemic infection and metastatic inflammation of glands that are the site of goiter may occur in connection with multiple pyemia and certain infectious fevers. The treatment is that of suppurative inflammation in general.

Goiter (Struma, Bronchocele).—Goiter may be denominated a true adenoma of the thyroid gland, though the term has been applied indiscriminately to all tumors of this structure. The different varieties of goiter may be

classified as follows: (1) **hypertrophy of the gland**; (2) **fetal adenoma**; (3) **gelatinous or intraacinous adenoma** (Wölfler). The first consists in a uniform increase in the gland tissue, is soft to the feel, and may be vascular and compressible. The second follows formation of gland tissue from the remains of fetal structure in the gland and is usually observed as one or more fine and movable nodules, varying in size from a hazelnut to an orange. The third consists in an increase in size of the acini, these being apparently dilated by the accumulation of colloid material and the growth of the intra-acinous tissue. **Cystic goiter** is a result of further liquefaction of this colloid material; irregularly dilated acinous spaces filled with straw-colored semi-liquid occur at one or more points in the tumor. **Mucous cysts** are sometimes found in the so-called accessory thyroid glands. These latter consist of displaced portions of thyroid tissue, the displacement occurring during fetal life. They are found in the neighborhood of the hyoid bone, where the mucous cyst is most frequently found, at the base of the tongue, behind the pharynx and esophagus, and behind the sternum.

Vascular goiter may deserve clinical recognition as a distinct variety, though pathologically it is an undue dilatation of the vessels, especially the arteries, which may occur in any of the forms of thyroid adenoma. It is characterized by **distinct pulsation and a perceptible bruit,** heard through the stethoscope. It may preserve the form of the gland or become crescentic in shape.

Finally, we may distinguish clinically **fibrous, calcifying** goiter, and **ossifying** goiter. These terms signify certain changes which any of the varieties of goiter may undergo in course of time.

Causes.—The disease may occur at any time of life and sometimes develops during pregnancy (hypertrophy of the gland). It occurs more frequently in females. It has been observed to develop after malaria, diphtheria, and typhoid fever. It may be either sporadic, endemic, or epidemic. It occurs endemically in certain mountainous districts on the continent of Europe and in the lowlands of rivers as well. These districts have a special geologic formation, the waters from which consist largely of magnesia (Grange). It has been noticed to occur epidemically in schools and garrisons (Warren). The special cause has not been discovered. Grange, followed by Lücke and Virchow, attributed the disease to a special **miasma,** while Bircher claimed to have discovered a special microorganism in the waters of the districts in which it is endemic.

The **growth** of goiter is extremely slow. Occasionally an acute form is observed (vascular goiter); it may quickly prove fatal from pressure effects on the trachea. In goiters of slow growth, sudden death may also occur from asphyxia, from paralysis of the posterior crico-arytenoid muscles due to pressure on the recurrent laryngeal nerve.

When the goiter has advanced sufficiently to cause stenosis and consequent dyspnea, the further growth is greatly accelerated by congestion in the venous channels. This is shown by the decided diminution in size of the enlargement within a few hours after a tracheotomy, a long tube being used.

Finally, an inflammatory swelling of the goiter (**strumitis,** Kocher) may produce a dangerous degree of tracheal stenosis. The inflammation may occur in connection with infectious diseases in septicemia and pyemia or it may arise

without discoverable cause and follow febrile catarrhal conditions of mucous membranes. If not arrested early by the application of antiphlogistic remedies and the injection of a 5 per cent solution of carbolic acid (Kocher), extensive suppuration and gangrene may occur.

The Relation of Goiter to Cretinism.—Cretinism is characterized by idiocy and imperfect development of the bones, particularly those of the skull. Both affections are found in the same localities and sometimes in the same individuals. In addition to this, it has been shown by statistics that half the number of cretins in these districts originate from parents who have goiter.

Exophthalmic Goiter (Graves's Disease).—This is a sporadic form of the disease characterized by a peculiar combination of palpitation of the heart (**tachycardia**), **exophthalmos,** and **thyroid enlargement.** The condition is supposed to have its origin in local nerve irritation giving rise to perverted function and finally to toxic effects from altered thyroid secretion (Greenfield, Mandl).

Temporary enlargement of the thyroid gland bears a certain relation to the female sexual life and appears at the time of menstruation. It depends on some obscure vasomotor influences.

Embolic distribution of portions of goiter, these proliferating in the thyroid veins, particles being swept in the blood-current and producing tumors at distant points, particularly in the medullary tissue of the bones of the extremities (W. Müller, Neumann), has been observed.

The **diagnosis** of goiter is not difficult, as a rule. It is to be differentiated from all other tumors in this region by the fact that it moves up and down with each act of swallowing. The only other tumor which presents this symptom is a hydrops of the thyrohyoid bursa mucosa. Nor is it difficult to differentiate the different varieties, both pathologically and clinically. Disturbances of function are not in proportion to the size of the goiter. Large growths may give rise to very slight disturbances and small growths to pronounced symptoms. Disturbances of deglutition are rare, except in cases where the disease attacks displaced portions of thyroid tissue behind the pharynx or esophagus (Czerny, Kocher). Disturbed respiration depends on the relation which the mass bears to the trachea. This may also occur in those cases in which the affection is present in a portion of thyroid situated behind the sternum. These so-called "plunging goiters" make a rapid downward movement behind the sternum during an act of inspiration and compress the trachea, to reappear during expiration. Goiters which grow backward easily compress the trachea from the fact that from one-fifth to one-third of the periphery of the tube is uncovered by cartilage behind; respiration is interfered with early in these cases. Lateral compression of the trachea between the enlarged lobes also interferes greatly with respiration, producing the so-called "scabbard trachea."

The Treatment of Goiter.—The external application of tincture of iodin, as well as of ointments of iodid of potassium formerly much in vogue, is now very generally deemed useless. The **internal use of iodid of potassium** has much to recommend it. It should be continued for months, being interrupted only because of intolerance of the drug, as shown by the symptoms of **iodism.**

A certain degree of success is obtained by the use of **injections of tincture**

of iodin (Luton and Lücke). From 10 to 15 drops of the tincture is injected, with antiseptic precautions, into the tumor every third or fourth day. The accidental entrance of the injected tincture into a large blood-vessel is followed by alarming symptoms of dizziness and fainting. This is to be guarded against by first introducing the detached needle and directing the patient to make movements of swallowing. If a large vessel has been entered, the drops of blood will follow one another in quick succession through the needle, and another place must be selected for the injection. The barrel of the syringe, previously charged, may then be screwed fast to the needle and the injection made. Strumitis terminating in suppuration occurring as a result of the injection is due to uncleanly manipulation. The method is applicable only to **simple hypertrophic goiter.** It is useless in goiters that have undergone fibrous, calcifying, or ossifying changes; it is contraindicated in the gelatinous variety and is highly dangerous in vascular growths.

The injection of alcohol (Schwalbe) is inferior to that of tincture of iodin. Injections of arsenic have not fulfilled the expectations of its originator. In Graves's disease a solution of extract of ergot to which carbolic acid has been added, injected into the connective tissue of the anterior region of the neck and not into the goiter itself, has been followed by favorable results (Caghill).

In cystic goiter, where a single cyst can be isolated and emptied by the trocar and cannula, this may be followed by an injection of from 15 to 30 drops of tincture of iodin. As this form of goiter is usually a further stage of development of the gelatinous or intraacinous variety, there is considerable danger of setting up acute suppuration. The occurrence of this will necessitate **incision** or **extirpation.**

The Operative Treatment of Goiter.—Treatment by setons has been abandoned. Attempts at cure by electrolysis are unsafe and have proved to be of but slight benefit when employed. Opening cystic goiters by the use of **chlorid of zinc paste** is mentioned only to be condemned.

Incision is indicated in suppurative inflammation and possibly in some cases of cystic goiter. To avoid dangerous hemorrhage the opening may be carefully made with the thermocautery. Even with this precaution there may be serious hemorrhage from the presence of vascular tissue in the cyst wall itself. The bleeding may be controlled by passing acupuncture needles across the base of the tumor and applying a constricting ligature beneath these. Where the cyst is quite superficial, it may be opened under asepsis with the knife, and the sac wall and skin stitched together.

Extirpation.—Owing to improved methods of hemostasis and asepsis, the radical cure of goiter by extirpation has become an established operation. It is to be recommended in progressive cases in which iodin injections have failed, and may replace incision in cases of cystic goiter demanding interference. Total extirpation of the thyroid gland is contraindicated by the probability of the occurrence of **cachexia strumipriva.** The operative methods available are (1) **excision;** (2) **enucleation;** (3) **resection.**

Excision (Kocher).—Disfiguring may be avoided by the use of the **transverse curved** or " **collar** " **incision,** with the concavity directed upward (Fig. 363). This is carried across the most prominent part of the swelling. The skin and platysma are divided and branches of the anterior jugular vein cut across between two ligatures. The fibers of the sternolaryngeal muscles,

sometimes greatly thinned, are exposed and separated vertically or divided in the line of the skin incision. When necessary, the anterior edge of the corresponding sternomastoid is nicked, when the tumor is freely exposed.

Fig. 363.—Kocher's Curved (Collar) Incision for Goiter.

When the tumor is large and it is desirable to avoid extensive division of the muscles, the angular incision is to be employed (Fig. 365). This begins over the prominence of the sternomastoid at the level of the thyroid cartilage and extends almost transversely in the direction of the skin-creases as far as the middle line of the neck, and thence vertically downward to the suprasternal region. In deeply situated goiters it is prolonged on to the manubrium sterni. The skin and platysma are divided in the transverse portion of the incision. The superficial fascia is now divided. The anterior jugular vein is divided between two ligatures. The anterior border of the sternomastoid is exposed at the outer extremity of the horizontal incision and thoroughly freed and drawn aside with blunt retractors. The fascia at the middle portion of its horizontal incision is retracted and the fibers of the sternohyoid and sternothyroid exposed. The two sets of sternolaryngeal muscles lying on each side are now separated in the vertical portion of the incision, freed, lifted up by passing the finger beneath them, and partially or completely divided and retracted by blunt hooks.

Fig. 364.—Goiter. Curved Incision. Muscles Exposed.

The thin layer of connective tissue which constitutes the outer capsule of the gland is now carefully divided and stripped to each side by blunt dissection; any veins which pass from the capsule to the goiter are divided between two ligatures. The capsule and overlying muscular structures are retracted, the finger passed around the outer edge of the tumor, and the latter carefully detached until the finger reaches the posterior surface.

The tumor is now drawn forward and the principal vessels ligated. The

relations of the recurrent laryngeal nerve to the inferior thyroid artery are such as to endanger this, unless the artery is carefully isolated and inspected before tying. Unless the operator is enabled positively to identify the nerve, only a provisional ligature should be applied.

The further isolation of the tumor is now proceeded with. The large inferior thyroid vein or its branches is put upon the stretch and divided between two ligatures. The superior thyroid artery is exposed by blunt dissection above the isthmus. The dissection is carried upward along the inner border of the upper horn, which is lifted carefully forward, and a ligature passed beneath the superior thyroid vessels, which are tied and divided. The isthmus is now carefully isolated and a strong silk ligature passed by means of a large aneurism needle, or Thiersch's ligature carrier and spindle, and tightened while the isthmus is being divided. The goiter is now lifted away from the trachea, to which its posterior border is still attached. In detaching the tumor from the trachea at this point, the recurrent laryngeal nerve is in danger of being injured in spite of every care. In order to guard against this, it is better for the surgeon to cut through the tumor parallel to the surface of the trachea, leaving behind a portion of the internal capsule. If the nerve has not been included in the ligation of the inferior thyroid, the tumor can now be completely removed. Otherwise another ligature must be applied and the first removed, after which the remaining attachments may be divided. The thermocautery may be employed to effect the separation of the goiter at the isthmus, the silk ligature being dispensed with.

Fig. 365.—Goiter. Angular Incision.

Enucleation (Porta, Socin).—This is applicable where single, large colloid or cystic nodules are to be removed. In these cases it is a simpler procedure than excision and possesses the additional advantage of preserving the healthy thyroid tissue. The tumor is to be exposed as in Kocher's operation, after which the healthy thyroid (internal capsule) over the nodules is incised and the latter shelled out. The hemorrhage is sometimes severe. To prevent this, the main vessels may be ligated preliminarily.

Resection of Goiter (Mikulicz).—This consists of resecting the diseased part of the gland. It can be only exceptionally applied, and should be resorted to only in cases in which the nodules are small and prominent and easily separable, or in cases of diffuse colloid degeneration in which the mass is not easily lifted forward for purposes of excision. Ligation of the vessels on one side should precede the resection in these cases. The thyroid tissue is sometimes very brittle and pressure forceps applied as angiotribes cut into it and cause

severe hemorrhage. The wound does not heal so readily as in typic excision on account of the large stumps of ligated tissue which become necrotic.

Enucleation Resection (Kocher).—The goiter is exposed as before, ligation of the main vessels, however, being omitted. The tumor is drawn forward and the isthmus ligated and divided. Access is gained to the nodule through the cut surface of the divided isthmus. The gland capsule is separated by blunt dissection and pressure forceps applied in an upward and downward direction. The tissues included in the forceps are then ligated, the forceps being gradually loosened as the ligatures are tightened. It may be necessary to repeat this maneuver in the neighborhood of the upper and lower poles. The posterior wall of the capsule is now incised vertically and the parts beyond the ligatures enucleated.

In closing the wound after thyroidectomy the head should be flexed slightly forward, the divided portions of the sternolaryngeal muscles united by chromicized catgut, and the external skin wound closed by the intracuticular or the chain suture.

When extirpation of goiter is performed on account of great difficulty of breathing, general anesthesia should be avoided, when possible. Local cocain anesthesia aided by morphin narcosis is to be preferred in such cases (Kocher).

Summary of important points in the operation of thyroidectomy: (1) Avoid resort to general anesthesia, as a rule. (2) Employ cocain and morphin whenever practicable. Among other advantages there is less danger of ligating the recurrent laryngeal nerve; the patient should be asked to count aloud when the attempt is made to secure vessels in the neighborhood of the nerve. (3) Sensitive patients with healthy chest organs may have ether or chloroform, if they urgently insist on it, during the operation. (4) Avoid antiseptics. Strict asepsis is to be established and maintained during the operation. (5) Make all incisions free, and, as far as possible, in the direction of the natural creases. (6) Make a timely and careful ligation of the vessels before division, thus insuring against excessive loss of blood and injury of the recurrent laryngeal nerve, whose location is masked by the flooding of the field of operation, and secondary hemorrhage. (7) The sternolaryngeal muscles and their nerve-supply should be considerately treated and disturbed as little as possible, else sinking in of the neck will follow. When necessary to divide the muscles, this should be done near their upper insertion.

The occurrence of **cachexia strumipriva** (Kocher), or **myxedema,** following total removal of goiter is characterized in the beginning by a sensation of general weariness and a sense of weight and coldness in the extremities. The movement of the limbs becomes slow and heavy and the speech is clumsy. The skin becomes bloated in appearance, particularly in the face, and this, together with the pallor and dullness of expression, gives an idiotic appearance to the patient. Mental power and energy are lessened, and patients are unable to continue their former occupations. The young are stunted in their growth. A general condition of hydremia is present, the skin and mucous membranes becoming markedly pale. The skin is everywhere edematous. The proportion of red corpuscles is lessened in the majority of cases. The impulse in the vessels is remarkably lessened. The entire clinical picture resembles the condition described as "cretinoid disease" (Gull), "myxedema" (Ord), and "pachydermatous cachexia" (Charcot). The resemblance is

still further augmented by the fact that the decrease in size of the thyroid gland is a marked and permanent feature in myxedema.

Typic cachexia strumipriva occurs only after extirpation of the entire thyroid gland. It follows the operation about twice as often in males as in females. The occurrence of **tetany** has also been observed to follow total extirpation of the thyroid (Weiss, Billroth, Mikulicz).

Paralysis of one recurrent laryngeal nerve from injury or contusion of the nerve during the operation not infrequently occurs. Hoarseness follows, and deglutition may be erratic on account of paresis of the epiglottis, particles of food passing into the glottis. Paralysis of the corresponding vocal cord is revealed by the laryngoscope. The breathing is not disturbed unless the paralysis is bilateral. The accident is sometimes unavoidable. It is to be noted that the condition is sometimes present before the operation, and the latter may relieve it. In any event, the voice usually improves, though laryngoscopic examination still reveals paralysis of the vocal cord.

Sarcoma of the thyroid gland sometimes develops, partly in old goiters, partly in normal tissue. It is characterized by rapid and enormous increase in the size of the gland.

Carcinoma occurs either in the medullary form with development of large soft masses in the tumor, or in the *scirrhous* form, in which there is shrinkage of the connective-tissue stroma, induration, and gradual decrease in the size of the growth. It is a disease of great rarity, except in districts where diseases of the thyroid are prevalent. It occurs between the ages of forty and fifty. In the early stages of the disease it may greatly resemble an ordinary goiter. The steady increase in the size of the gland, its nodulated outline, the occurrence of pain, and paralysis of the recurrent laryngeal nerve as infiltration proceeds, together with a certain fixity of the gland, constitute the characteristic symptoms. Disturbances of respiration and radiating pains are said to be pathognomonic of fibrous carcinoma or scirrhus of the thyroid gland.

Dissemination takes place rarely, unless the condition known as **general thyroid malignancy,** described by Cohnheim, constitutes an expression of such dissemination occurring in connection with the very earliest stages of overlooked cancer of the thyroid. In the condition in question, tumors structurally identical with the thyroid gland are formed in the bones in individuals affected with enlargement of the gland. These growths appear more frequently in women than in men. Cases have been reported in which tumors were found on the bones of the skull, for which they seem to have a predilection. They have also been found in the following situations, mentioned in the order of frequency of occurrence of the tumors: the femur, clavicle, sternum, and vertebrae. The growths may attain a considerable size, and in some instances pulsation has been a marked feature.

Operative treatment in these secondary tumors, when they have appeared in accessible situations, has been followed by satisfactory results.

THE ESOPHAGUS

Injuries.—Of injuries of the esophagus the majority are **incised wounds; gunshot wounds** are observed next in frequency and **punctured wounds** least of all. The first occur almost exclusively in connection with suicidal attempts.

The prognosis in this class of cases, other things being equal, is in proportion to the extent of the separation. Tracheotomy is at once performed and the wound in the esophagus closed with chromicized catgut. The patient is fed by means of a stomach tube. In transverse separation of the larynx and esophagus the wound may gape widely in spite of every effort, a permanent fistula becoming established. A plastic operation may be necessary to cure the defect.

Punctured and **shot wounds** of the esophagus alone are rare. The latter is usually injured from the side. In all of these cases the swallowed food escapes through the wound for a short time only, the latter finally closing by granulation and cicatrization. In order to prevent phlegmonous inflammation of the connective-tissue planes of the neck from lodgment of food in the wound track the patient should be fed by the stomach tube until granulations are formed.

Transverse rupture of the esophagus from forcible efforts at vomiting has been observed (Boerhave). Death usually follows from mediastinitis.

Injuries from swallowing caustic substances derive their chief surgical importance from the **cicatricial stenosis** of the tube which subsequently follows. In the case of acids the immediate treatment consists in the administration of harmless alkalis, such as chalk or lime water; and in the case of alkalis, vinegar or fruit acids.

Instrumentation of the Esophagus.—The use of the **esophageal bougie** is of service in the diagnosis of diseased conditions of the esophagus. By means of it, altered conditions of the wall of the esophagus may be quite satisfactorily made out.

The stomach tube is employed for purposes of artificial feeding. The instrument is best made of thick-walled rubber tubing, with a smooth-edged extremity, or a lateral velvet-edged opening near the end.

Before introducing the stomach tube the distance from the lips to the hypochondrium should be measured, in order to avoid introducing the tube too far. In the normal esophagus the tube is arrested at a point directly behind the cricoid cartilage, at which point the latter approaches the vertebral column. In order to overcome this resistance the larynx is drawn forward by placing the tip of the index-finger of the left hand in the depression between the epiglottis and the tongue, and drawing the parts forward through the medium of the glosso-epiglottic ligament. Simply bending the finger sharply against the base of the tongue usually suffices, the point of the tube being at the same time directed toward the posterior pharyngeal wall and passed downward. The patient is then directed to make efforts at swallowing. The tube passes without further resistance into the esophagus. For purposes of artificial feeding, the tube is connected to a glass funnel. The fluid must be introduced slowly, otherwise efforts at vomiting will be provoked. In cases of injury of the pharynx and esophagus, and after certain operations about the neck (extirpation of the larynx, etc.), the frequent introduction of the stomach tube may do harm. Retention of the tube *in situ* by means of a safety-pin passed through its wall, to which a tape is secured and passed around the neck and tied over the dressings, is here indicated.

The stomach tube is also used for washing out the stomach (**lavage**), the fluid which has been introduced being withdrawn by simply lowering the glass funnel to which it is connected just before it is empty. The tubing which connects the funnel to the stomach tube being longer than the portion which occupies

the esophagus, a siphon effect is produced and the stomach is promptly emptied. It may be refilled and emptied in this manner as often as required.

When the patient resists, as the insane, a proper sized tube may be passed through the nasal cavity and thence to the stomach. In children a gag may be used. If this is not at hand, the operator may avoid injury of his finger from the little patient's teeth by forcing the lip in with the finger. The patient then bites his own lip.

Foreign Bodies in the Esophagus.—Round, smooth foreign bodies that have been swallowed usually find their way without difficulty into the stomach, and, in the course of time, are passed *per anum*. When retained, however, their retention is due to convulsive contractions of the tube, the foreign body being arrested either behind the cricoid or at the cardiac orifice. In children pieces of coin, buttons, etc., are swallowed and lodged in the esophagus. Pins carelessly held between the teeth sometimes find their way into the mouth and are swallowed. Imperfectly masticated pieces of meat, bones taken with the food, and, finally, artificial teeth have been lodged in the esophagus. These latter may produce fatal suffocation by pressure on the trachea. One-fourth of the fatal cases of foreign bodies in the esophagus perish from asphyxia (König).

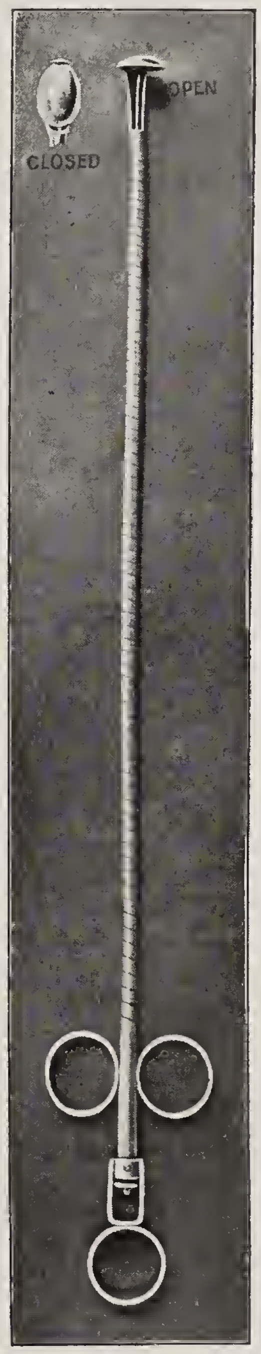


Fig. 366.—Graefe's Coin Catcher.

Wounds of the esophagus from pointed and angular foreign bodies are particularly dangerous. Pins and needles may perforate the tube, migrate from muscular action, and enter a large vessel (aorta, carotid), causing death from hemorrhage. Those perforating low down may enter the heart. A bronchus may be invaded. They may appear beneath the skin of the neck and be removed by a simple incision. Artificial teeth on plates with projecting angles, bits of glass, pieces of bone, etc., wound the tube in their passage downward and produce ulceration or necrosis from pressure. The wall of the esophagus is perforated, food enters the periesophageal connective tissue, and extensive and fatal suppuration frequently follows. The mediastinal space, or the pleural cavity, may thus become the seat of suppurative inflammation. The trachea may be invaded, an **esophageotracheal fistula** resulting, with fatal termination.

The **diagnosis** of foreign bodies is to be based on the history, the existing difficulties of swallowing, and particularly the results of examination by means of the esophageal bougie. It sometimes happens that the foreign body has passed into the stomach and the symptoms are due to injuries inflicted during the passage. Metallic foreign bodies, if not completely embedded, may be located by means of the Röntgen rays or the telephone probe.

Treatment.—Large masses of meat, etc., as well as smooth bodies, are to be pushed into the stomach by means of a whalebone bougie with a piece of compressed sponge attached.

This instrument may be used for both propulsion and extraction. When

for the former, it is passed down to the mass and there allowed to swell and fill the entire esophagus. When used for extracting a foreign body, it is passed below the latter, and, after swelling, is withdrawn.

All pointed and angular bodies must be removed from above. Fish-bones, unless very large, seldom do harm after reaching the stomach, the gastric juice attacking and softening them. While most swallowed coins will pass through the entire intestinal tract without doing harm, yet it is best to extract them when possible. The instrument of Graefe is useful for this purpose (Fig.

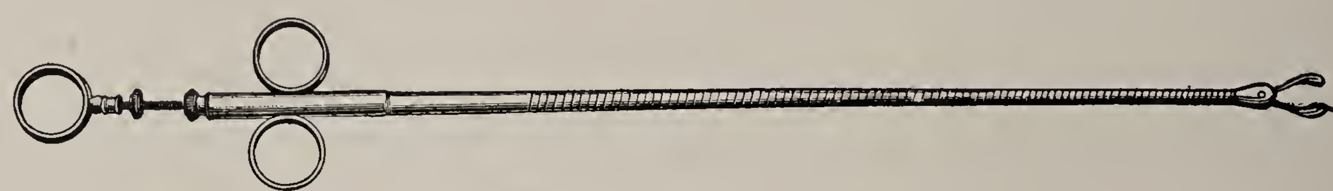


FIG. 367.—FLEXIBLE ESOPHAGEAL FORCEPS.

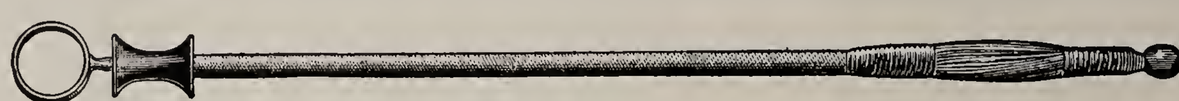


FIG. 368.—UMBRELLA PROBANG CLOSED FOR INTRODUCTION.

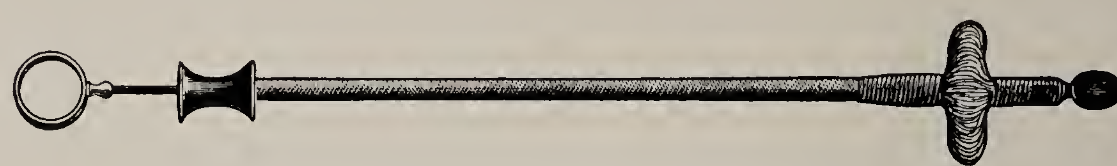


FIG. 369.—UMBRELLA PROBANG OPEN FOR EXTRACTION.

FIG. 370.—ESOPHAGEAL FORCEPS, BLADE OPENING LATERALLY.

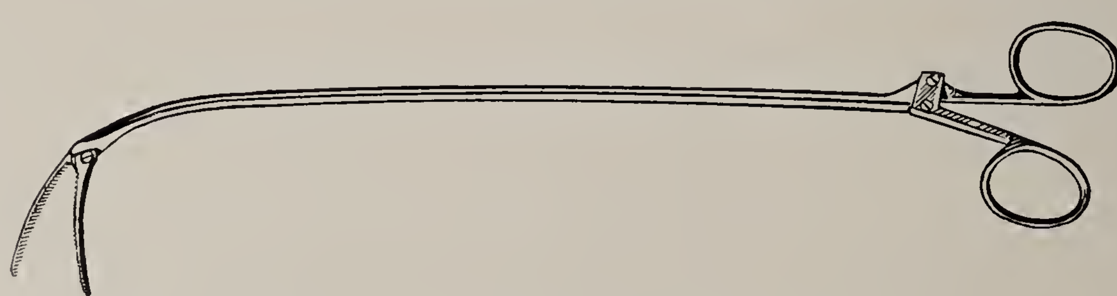


FIG. 371.—CURVED ALLIGATOR FORCEPS.

366). The basket attachment should be as wide as the esophagus will admit. The flexible esophageal forceps is also a useful instrument (Fig. 367). The **umbrella probang** (Sayre, Weiss, Fig. 368) serves for the extraction of fish-bones, etc. It sometimes happens that, by means of this instrument, a fish-bone may be loosened and placed longitudinally in the esophagus, passing subsequently to the stomach. For foreign bodies high up, forceps with blades opening laterally are to be preferred (Fig. 370), for the reason that this form will accommodate itself best to the longest diameter of the esophagus.

In extracting foreign bodies from the esophagus the index-finger of the left

hand should be passed to the base of the tongue ready to steady the foreign body as it enters the pharynx, and prevent it from falling into the glottic opening. Cocainization of the accessible parts will assist in the manipulation. The grasping and extraction of a metallic foreign body may be accomplished under the guidance of the *x*-rays. (For cutting operations for the removal of foreign bodies, see Esophagotomy.)

STRICTURES, TUMORS, AND DIVERTICULA OF THE ESOPHAGUS

Strictures arising from **syphilitic and tuberculous ulceration** are exceedingly rare. **Esophagitis** in the proper sense scarcely ever exists.

Cicatricial strictures are commonly a late effect of swallowing caustic fluids. A slough is cast off and gradual condensation of the resulting cicatrix produces stenosis. Weeks and in some cases months may elapse before symptoms of obstruction appear.

Epithelial carcinoma is a frequent cause of stenosis of the esophagus. It usually occurs at the level of the cricoid cartilage. The next most frequent points of attack are near the cardiac orifice, and at the point where the tube is crossed by the left bronchus. It is most common between the ages of forty and sixty. Of the cases, 75 per cent occur in men. Lymphatic glandular infection occurs at the root of the neck, in the mediastinum, or in the lumbar region, according to the point of location of the disease.

The disease is insidious in its first symptoms, but runs a rapid course, death resulting from inanition due to obstruction, from septic pneumonia and pleurisy following perforation of the trachea, or from mediastinal abscess and perforation of the pleura or of the pericardium. Two or more points of stricture may be present from longitudinal extension of the disease. The **diagnosis** is established with the aid of the whalebone bougie à boule. If ulceration has taken place, evidences of this may be present on the bougie when withdrawn.

Fibromas and **myxomas** may grow from the mucous membrane and become pediculated from acts of swallowing (**polypi of the esophagus**). They occur by preference behind the cricoid cartilage. Deglutition is interfered with, and respiration as well, particularly when the polypus, being forced upward, lies across the glottic opening. These growths are best dealt with by being lifted up in the act of vomiting, after an emetic has been administered, and seized with forceps and severed by means of the galvanocautery loop. If removed with the scissors, the pedicle must first be ligated to avoid troublesome hemorrhage.

Compression of the esophagus may result from the pressure of tumors from without, particularly in cases of carcinomatous goiter.

Diverticula are mainly of congenital origin and may bear some relation to congenital fistula of the neck (B a r d e l e b e n). They develop, or may even originate, late in life. Anatomically they may consist of both mucous membrane and the muscular coat, or the former may, hernia-like, pass through an opening in the latter. **Dilatation of the esophagus** (**ectasia**) may take place in connection with stricture from any cause or independently of this. Spasm of the cardiac orifice having its origin in reflex neurotic disturbances or occurring as a hysteric manifestation may give rise to either of these conditions. Finally, diverticula may arise from traction on the esophagus from without from enlarged lymphatic glands (**traction diverticula**) or from pressure from within (**propulsion diverticula,** Z i e m s s e n).

The accumulation of food in the esophagus and its rejection undigested result from increase of capacity of the pouch. When sufficiently marked to attract attention, the whalebone bougie à boule will establish the diagnosis.

Small diverticula may produce no inconvenience for a long time. Their tendency is to increase, however, and inability to obtain sufficient nutriment may render starvation imminent. Under these circumstances gastrotomy should be performed and the cardiac orifice thoroughly and efficiently overdilated to overcome the tendency to spasm (Mikulicz). The opening in the stomach wall is then closed. Exceedingly good results have followed this procedure in the hands of its originator.

When symptoms of stricture of the esophagus arise as a part of the complexus of symptoms constituting the condition known as hysteria (**hysteric dysphagia**), the occasional passage of the bougie for its moral effect is usually sufficient for cure.

The Treatment of Stricture of the Esophagus.—The **preventive treatment of cicatricial stenosis,** consisting of the systematic introduction of an esophageal sound or bougie, should be instituted in about the third week after the accident of swallowing caustic fluids. At first daily séances, followed by weekly and finally by less frequent ones, are indicated, as in urethral stricture. The case comes to the surgeon, however, only after difficulty in swallowing is experienced. Small bodies (kernels of nuts, lemon seeds, etc.) may lodge at the point of stricture and produce ulceration, necessitating esophagotomy.

Gradual dilatation (Trousseau) is carried on by means of the bougie à boule. Gradually increasing sizes are employed three or four times a week when the parts are irritable, and daily when the parts are tolerant or the symptoms urgent. In adults sizes from 35 to 40 (French) may be reached, after which the largest size possible is to be passed occasionally to insure patency of the lumen, the stricture tending to constant recontraction.

In cases of cicatricial stricture a **temporary gastrotomy** should be performed and an effort made to pass an instrument from below. If successful, Abbe's bowstring method of dividing the stricture should be employed (*vide infra*). In case of failure to pass the stricture with the smallest instrument, a permanent gastric orifice should be established for feeding purposes (see Gastrostomy).

External Esophagotomy.—When the stricture is situated in the cervical portion of the esophagus and is accessible from without, it may be divided from the latter direction, and narrow circular strictures may even be excised (resection of the esophagus, Billroth). Dilatation must be subsequently employed to prevent recontraction.

Internal Esophagotomy.—Strictures of the thoracic portion not amenable to gradual dilatation have been subjected to incisions from within, and for this purpose **esophagotomes** (Maisonneuve, Sands, Mackenzie) are employed (Fig. 372). Here also recontraction must be provided against by the occasional subsequent introduction of a dilating instrument. In performing the operation care must be taken not to cut through the wall of the esophagus. The latter is simply nicked at one or more points to permit the introduction of dilating instruments. The exact status of the operation has not yet been determined.

Abbe's method of treatment consists in performing a gastrotomy and passing one end of a string from the opening in the stomach through the esophagus and out of the mouth by means of a gum elastic catheter or other instrument that will pass the stricture. The string is then made tense and drawn rapidly back and forth until the stricture is divided. The gastrotomy wound is then closed. Recurrence is prevented by the frequent introduction of esophageal bougies.

Intractable strictures require the establishment of an **esophageal fistula** in the cervical region, if they are situated sufficiently high up, or **gastrotomy.** In the former case the esophagus is opened low down in the neck and its mucous membrane sutured to the skin; or it may be completely divided and secured by suturing into the external opening (**esophagostomy**). (For making an artificial mouth at the stomach, see Gastrostomy.)

In **carcinomatous stricture** the treatment resolves itself into operative methods designed to prevent the patient from starving to death. Further, the withdrawal of food from the natural passage and the substitution therefor of artificial feeding through an esophageal fistula, or a gastric mouth, will retard the progress of the disease by removing the irritation arising from the attempt to force food through the narrowed lumen of the tube. *Attempts at dilatation are absolutely contraindicated.*

The Operation of External Esophagotomy.—The indications for the

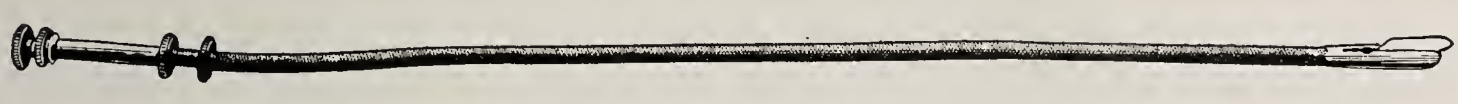


Fig. 372.—Roe's Modification of Mackenzie's Esophagotome.

operation have already been discussed (viz., foreign bodies, strictures, and possibly diverticula). When a large foreign body is situated high up in the tube and can be felt from without, this may form a sufficient guide for the incision. Or, when practicable a curved sound may be introduced and the parts made prominent by pressure from within. The left side is to be selected for the opening, on account of its greater accessibility. It is covered almost entirely by the trachea on the right side. When necessary, as, for instance, when a left-sided goiter complicates the case, the opening may be made on the right side.

The incision is made along the anterior edge of the sternomastoid muscle. The platysma myoides and superficial fascia are divided, and by retracting the inner edge of the sternomastoid outward and the sternothyroid inward, the omohyoid is exposed. If necessary, this may be divided. If the operation is performed on a level with the larynx, after the thyroid fascia is divided the gland itself is drawn inward. The inferior thyroid artery, if necessary, may be divided between two ligatures. It lies on the longus colli at this point. The carotid artery is drawn outward with a blunt retractor. The esophagus and lateral edge of the trachea are now exposed. Care must be taken at this point not to injure the recurrent laryngeal nerve, which passes between the esophagus and the trachea toward the outer aspect of both organs. The esophagus is recognized by its pale red color and longitudinal muscular fibers. If a sound has been previously introduced as a guide, the tube may be opened upon this. It is difficult to open it in the collapsed state. This opening is to be made on its

lateral aspect and should be large enough to introduce the index-finger; it may be enlarged subsequently, if necessary. If the operation is performed for the removal of a foreign body, the esophagus may be closely sutured with fine chromicized catgut, but the remainder of the wound is to be left open to avoid infiltration, should the esophageal sutures give way. If for stricture, this may be dilated, or, if this is intractable or carcinomatous, the mucous membrane is to be stitched to the skin (**esophagostomy**), and a permanent opening established for purposes of artificial feeding.

Resection of the esophagus (**esophagectomy**) was suggested by Billroth (1870) after experiments on animals. Later, Czerny (1873) performed the operation for annular carcinoma in the cervical portion of the esophagus in a woman of fifty-one. The patient was able to take food through the opening left, but died from local recurrence fifteen months later. Mikulicz has reported 10 cases. Rose operated successfully in 1887.

THE LATERAL REGION OF THE NECK

A line drawn from the mastoid process to the inner third of the clavicle limits the area in this region within which punctured, incised, and gunshot wounds endanger life. Here, passing in a vertical direction, are found the carotid artery, internal jugular vein, and, more deeply placed, the vertebral artery and the pneumogastric, sympathetic, and phrenic nerves. Just above and partly behind the clavicle are placed the subclavian artery and vein, and above is the brachial plexus. It is a matter of surprise how frequently the vessels in this region escape in cases of punctured and gunshot wounds of the neck. This is due to the elasticity of their walls. The latter, however, may become contused, in which case a slough occurs and fatal hemorrhage frequently follows. Contour shots in this neighborhood are not uncommon, a sudden turn of the head at the moment when the ball strikes accounting for these.

In suicidal wounds of this region the larynx usually receives the greatest injury. The weapon may, however, reach the anterior edge of the sternomastoid muscle and even open the common carotid artery.

Operation wounds occasionally divide the platysma, omohyoid, digastric, and stylohyoid muscles. These, however, are not of special importance; even partial or complete extirpation of the sternomastoid does not produce serious functional disturbances.

Rupture of the sternomastoid muscle in the child during delivery sometimes produces **torticollis** (**wryneck** or **caput obstipum** of the newborn).

Hemothorax, pneumothorax, and **pyothorax** may result from punctured wounds affecting the lower portion of the neck, the projecting portion of the pleura in this region being involved.

Deforming Cicatrices of the Neck.—These result from extensive burns. While they may be sometimes obviated in a measure by means of early aseptic treatment and skin transplantation, they are frequently unavoidable. In addition to the cicatricial contraction of the skin and subcutaneous connective tissue, the platysma myoides and its connections are affected, the deformity extending beyond the parts originally involved in the burn to the lower lip and angles of the mouth (Fig. 373) and eye. The **treatment** consists in dissecting away the entire cicatricial mass when practicable

and supplying its place with transplanted pediculated flaps. When this is not feasible, the cicatricial band is to be completely divided, the position of the head corrected to hyperextension, and a flap of skin with pedicle transplanted to fill the defect (Blasius). Or, the method by double pedicle may be employed. This consists in raising the flap of healthy adjoining skin, leaving it attached by both ends, but loosening it entirely in the middle and passing a strip of oiled silk beneath it to prevent reunion to the parts beneath. When a granulating surface has been secured on the raw surface of the flap, this is severed at one end, deprived of its granulating surface by paring, and the gap left by the division of the cicatrix and reduction of the deformity filled with the flap (Croft). Fixation apparatus is to be applied to keep the parts at rest and maintain the head in position.

Fig. 373.—Contraction of Cicatrix and Platysma Myoides Following Burns.
The lower lip and angles of the mouth are practically obliterated. Dr. Everson's case

Injuries of Cervical Nerves.—Injuries of the cervical **sympathetic nerves** may result in paralysis of the vasomotor supply, as shown by flushing, or a red blush on the corresponding side of the face (see Cervical Sympathectomy).

The **pneumogastric nerve** may be injured by operations about the neck. Death usually follows within a few days, though recoveries after this accident have been reported. In one case excision of a portion of the pneumogastric nerve in a patient was not followed by serious disturbances, other than paralysis of one vocal cord (Billroth). Interference with respiration, however, is the rule.

Injury of the **phrenic nerve** results in paralysis of half of the diaphragm, and life is endangered, in spite of the fact that the other half of the diaphragm and the other respiratory muscles continue to act.

The **spinal accessory nerve** may be injured during operations for the removal of tumors lying between the external edge of the sternomastoid and the anterior edge of the trapezius. The function of the sternomastoid is not greatly interfered with, and the levator anguli scapulae supplies to some extent the place of the trapezius.

Division of **individual branches of the cervical plexus** is not followed by serious results on account of their free communication with branches of the fifth cranial nerve above and the brachial plexus below.

Injuries of the **recurrent laryngeal nerve** have been discussed in connection with excision of goiter.

The **hypoglossal nerve** may be injured during operations about the angle

of the jaw, the injury resulting in paralysis of one half of the tongue. Upon projecting this organ it is found to point toward the uninjured side, this paradoxic symptom being due to the action of the geniohyoglossus muscle, the radiating fan-like fibers of which, shortening only on one side, cause the healthy side of the tongue to approach the point of insertion of the muscle in the middle of the jaw.

The symptoms of injury of the brachial plexus in the neck will vary according to whether the roots of the median, radial, or ulnar nerves are involved.

The Treatment of Intractable Facial Paralysis by Nerve Anastomosis.—Experimental observations and operations in man have shown that cortical impulses may be made to reach a group of muscles from which the normal neural connections have been cut off. Even in the case of mixed nerves both motor and sensory functions have been restored. Well authenticated instances are not wanting in which an anastomosis between a paralyzed nerve and a neighboring healthy nerve has resulted in a cure of the paralysis. The distressing conditions present in facial paralysis may be remedied in some instances by establishing an anastomosis between the peripheral portion of the seventh nerve and either the spinal accessory nerve, the hypoglossal nerve, or a motor branch from the cervical plexus. In case the spinal accessory is selected for the purpose, emotional movements of the face are accompanied by disfiguring movements of the shoulder (Cushing).

The operation is usually indicated in paralysis secondary to middle-ear disease, operations, injuries, and fractures of the base of the skull. In cases of stab wounds in which the nerve is known to be cut across, and in which primary suture is impossible, the operation should be performed at once. In other cases electric treatment and massage should be persevered in for at least six months, at the end of which time, provided the presence of muscular fibers on the paralyzed side of the face can be demonstrated by electricity, the operation should be performed.

The operation of choice consists in implantation of the facial on the hypoglossal nerve (facio-hypoglossal anastomosis, Ballance and Stewart). The hypoglossal nerve is exposed above the posterior belly of the digastric. The incision is planned so as to include the peripheral portion of the seventh nerve, and the twelfth nerve at the point mentioned. The facial nerve is most easily exposed by incising the posterior border of the parotid gland (Cushing). The hypoglossal should be very carefully manipulated during the operation, lest paralysis of one side of the tongue follow; the least possible amount of suture material should be used. Only the nerve-sheath should be included in the sutures. Noticeable improvement may be expected at the end of three months. This should be assisted by electricity and massage.

Injuries of the Vessels.—In punctured, incised, and gunshot injuries of the large arteries of the neck and their branches (innominate, subclavian, and common carotid) the hemorrhage usually proves fatal before the arrival of surgical help. In **provisional arrest of hemorrhage from the carotid** the trunk of this vessel may be pressed with the finger against the transverse process of the sixth cervical vertebra (Chassaignac's carotid tubercle). Bleeding from the collateral current is to be arrested by pressure either immediately above the wound or in the wound itself. The **subclavian** may be pressed from behind the clavicle against the first rib in lean individuals

after depressing the shoulder; in stout persons and when the shoulder cannot be sufficiently depressed, this may fail. The hemorrhage may then be arrested by making pressure from before backward so as to compress the artery against the middle scalenus muscle and the transverse process of the seventh cervical vertebra. This failing, the method of strongly adducting the arm and placing the elbow in the epigastrium and the hand on the opposite shoulder may be tried. By this maneuver the clavicle is brought firmly down on the first rib and the vessel compressed between the two bones. Finally, direct pressure may be made upon the artery by the finger through an incision made in the cervical fascia. If hemorrhage persists from a wound of the carotid after the latter is firmly compressed against Chassaignac's tubercle, the bleeding comes through the vertebrals, which cannot be compressed by manual pressure.

With temporary arrest of the bleeding the patient's head is to be lowered, if he feels faint or the pulse is greatly weakened, and bandages applied to the extremities to force the blood into the trunk and head (autotransfusion). When the patient rallies, the wound is to be explored and both ends of the vessel secured by ligature. If this is found to be impossible, ligation in continuity is to be resorted to.

After the permanent arrest of the hemorrhage, should the patient's life be threatened from acute anemia, **infusion of salt solution** should be employed (see page 351).

Incised wounds of large **venous trunks,** particularly of the innominate and internal jugular veins, are almost invariably fatal, both from loss of blood and from entrance of air. In gunshot and punctured wounds gaping is not so great, at least in case of the jugular vein, and compression may be effected by placing the finger directly in the wound until a graduated compress can be applied. If the hemorrhage recurs, the parts must be explored and the vein ligated both above and below the wound. If the wound of the vein is small and involves only one wall, **lateral ligation** is indicated. Of the superficial veins, the **external jugular** is most easily injured, particularly in operations in this region. To avoid entrance of air it should be ligated before division. If not easily discernible, it may be brought out prominently by pressure immediately above the clavicle.

Inflammations in the Lateral Cervical Region.—Inflammatory conditions in the cervical region spread easily on account of the loose layers of cellular tissue which connect the muscular tissue and organs in this locality.

Abscesses may arise from different neighboring organs, such as the parotid gland, the submaxillary gland, and the cervical vertebrae (**migrating abscesses**). Those arising from the glandular structures are more superficial and may be opened early, so that diffuse phlegmon of the neck is prevented. Those arising from the cervical vertebrae are more deeply placed, and are scarcely recognized until they appear at certain points.

Lymphadenitis of the lateral cervical region is a very common affection. The affection may be divided into that having a tuberculous origin with cheesy infiltration, and the true inflammatory variety arising from septic infection and proceeding rapidly to suppuration. In both varieties the immediate source of infection is the lymph-current.

Tuberculous lymphadenitis is characterized by its chronic course and by

the fact that several neighboring glands are simultaneously attacked. The affection is not infrequently bilateral. Either the swollen structure of the gland becomes the seat of a slowly developed cheesy infiltration, or suppurative changes occur in it, the capsule being perforated and the connective tissue surrounding the gland becoming involved (**paradenitis**). Even under these circumstances the course of the affection is slow and rarely ends in destruction of the entire gland. The entire organism may be endangered by tuberculous infection, either from the cheesy glandular infiltration, or from the bacilli present in the fistulous tracks which lead to broken-down foci within the glands. Should a fair trial of intraparenchymatous injections of iodin fail (see page 112), early and radical extirpation of diseased glands, particularly when these have become the seat of cheesy metamorphosis, or of suppurative changes, is indicated.

Septic Lymphadenitis.—The infection originates in the buccal or pharyngeal cavity, and attacks, as a rule, but a single gland. The inflammation usually pursues an acute course, ending either in early resolution or in suppuration. In the latter case the capsule is perforated and suppurative paradenitis or even phlegmonous inflammation of the neck ensues. When arising from glands just beneath the superficial fascia, this form is comparatively harmless; it points early and is easily managed by incision. When originating from glands more deeply situated or extending to the area of the middle cervical fascia through the medium of the perforating lymph-channels of Ludwig (**Ludwig's angina**), the suppurative process may follow the sternothyroid muscle to the space between the anterior surface of the trachea and the depressors of the hyoid bone (the previsceral space of Henle), or along the inner surface of the sternomastoid, or the perivascular connective tissue of the large vessels, to the anterior mediastinum (**suppurative mediastinitis**). Under these circumstances the affection is accompanied by high fever and other alarming symptoms of a septic character, and sometimes passes entirely beyond surgical control. If the area of the deep cervical fascia is invaded, it may reach the retrovisceral space between the esophagus and the vertebral column, in which case a fatal result almost invariably follows. In addition to high fever and marked pain, difficulty in swallowing is complained of. Therefore, in the **treatment** of septic lymphadenitis, the more deeply **phlegmonous paradenitis** penetrates, the more urgent the necessity for early interference. The suppurating focus should be exposed by careful and formal dissection, as for the removal of a deep tumor from this region, injury of the vessels being avoided by separating natural lines of cleavage by means of the blades of anatomic or hemostatic forceps. The search must be persisted in until the source of the suppuration is reached.

Congenital Hydrocele and Other Cystic Tumors of the Neck.—Congenital hydrocele of the neck is a cystic formation found most frequently between the hyoid bone and the mastoid process, and also in the region of the external carotid artery and supraclavicular fossa. The tumor increases gradually in size and is the result of accumulation of secretion from its walls, lined with layers of pavement or of ciliated epithelium. These walls represent unobliterated portions of the branchial clefts (**branchial cysts**). They may extend to the styloid process, to the hyoid bone, to the anterior pharyngeal wall, or even to the anterior mediastinum. The contents of these cysts may be light-

colored and serous, or mucuslike, containing crystals of cholesterin. The **atheromatous cysts** sometimes found in immediate connection with the sheath of the carotid artery probably belong to the same class. These may also contain cartilage (**auricular teratomas** of Virchow).

Treatment.—A certain degree of success follows the method of emptying the cyst and injecting tincture of iodin or Lugol's solution. The injections may be repeated several times, if necessary (Esmarch). Incision and drainage may also be employed (Bardeleben). Extirpation of the sac, however, is the most trustworthy method of cure, though the operation is difficult and not unattended with danger.

Congenital fistula of the neck results from failure of closure of a branchial cleft (**branchial fistula**). This may be bilateral (18 out of 82 cases, according to G. Fischer). It may be hereditary. The fistula is usually situated at the lower third of the anterior edge of the sternomastoid muscle, near the sternoclavicular articulation. It usually takes a direction upward and toward the median line and sometimes communicates with the pharyngeal cavity. The inner wall of the fistula is lined with ciliated epithelium (Roth). These fistulas have been successfully treated by injections of tincture of iodin (Rehn and Serres). The galvanocautery has been recommended (G. Fischer). Excision of the fistulous track has been successfully performed (Hueter).

Median congenital fistula of the neck (**tracheal fistula**) has been observed. Though this is said to occur only in women (Bardeleben), I have seen it in both sexes. The fistula passes directly backward to the trachea, without invading it, however.

Branchiogenous carcinoma, or carcinoma having its origin in the epithelial structure of unobliterated branchial clefts, has been observed (Volkmann, P. Bruns).

Congenital Cystic Hygroma.—This is a multilocular cystic formation which sometimes originates in the submaxillary region. It may extend over the entire lateral and anterior region of the neck. The surface of the tumor is lobulated, the lobes corresponding to the individual cysts. The contents are serous and yellowish in color or brownish from admixture with decomposed blood. The inner wall is lined with a layer analogous to the epithelium of lymph-vessels, and the cyst cavities can sometimes be demonstrated as communicating with the lymph-spaces of lymphatic glands (Winiwarter, Wagner and others). Hueter proposed the name **congenital lymphangiectasis,** and Wagner **congenital lymphangioma.** The growth sometimes forces its way through the intramuscular spaces until it reaches the vertebral column. Its presence may cause interference with respiration.

Treatment.—Temporary relief may be obtained by puncturing several of the cysts and emptying them of their contents. Injections of tincture of iodin are contraindicated because of the ramifications of the growth and the probable occurrence of deep-seated and perhaps violent inflammation. Isolated and superficial cysts may be extirpated.

Blood cysts, apparently arising as a congenital formation, may develop later in life. They communicate with one or more veins of the lateral region of the neck. Hueter extirpated one of these tumors, which proved to correspond in situation to the internal jugular vein. These cysts contain partly liquid

and partly coagulated blood. The walls are sometimes covered with blood-clot in process of organization. In the **treatment** of these cysts injections of tincture of iodin are contraindicated on account of the danger of their entering the veins and reaching the right heart. In extirpating the tumor care must be taken not to injure the cyst wall, as hemorrhage from the communicating veins may be dangerous.

Echinococci of the lateral region of the neck are rare. Two cases successfully operated on are recorded (Hueter). **Cystic goiter** has been already discussed (see page 611). **Noncongenital hydrocele of the neck** (Madelung) probably arises as a cyst of the thyroid isthmus or of the third lobe, sometimes called the pyramid.

Hydrops of the Thyrohyoid Bursa.—This is a dropsy of the bursa which exists between the layers of the thyrohyoid membrane in the space where these are separated from each other. A flattened and fluctuating tumor may develop from accumulation of the secretion of the bursa, probably induced by infection. The skin becomes thickened and reddened and the adjoining connective tissue is infiltrated, resembling Ludwig's angina. The center of the latter, however, always lies near the angle of the jaw. The **treatment** consists in free incision and subsequent open dressing of the wound, the latter being allowed to heal by granulation.

TUMORS OF THE SKIN, MUSCLES, AND VESSELS OF THE NECK

Angiomas, nevi pigmentosi, atheromas, lipomas, papillomas, and **fibromas** occur occasionally in the skin of the neck.

Neoplasms of the cervical muscles are rarely observed. The fusiform swelling of the sternomastoid, occurring at delivery and followed by wryneck (see page 650), is sometimes mistaken for a tumor. **Sarcoma** having its origin in the connective tissue of the sheath of the muscles is rare in the lateral cervical region, as compared with its occurrence in the posterior cervical and scapular regions. **Syphilitic gummas of the sternomastoid** have been observed.

Aneurism of the large vessels in the lateral cervical region is not infrequent. The disease attacks the vessels most frequently (1) at the bifurcation of the common carotid into the external and internal carotid; (2) at the division of the innominate artery into the right subclavian and right common carotid. Other portions of the vessels may also be attacked, though less frequently. The presence of a **cervical rib** (an abnormal lengthening of the transverse process of the seventh cervical vertebra) is said to be an occasional cause of subclavian aneurism at the point where the vessel passes over the process (G. Fischer).

The **diagnosis** of aneurism is based on the symptoms already described (see page 97). The bruit can be made out in the pulsating tumor by both auscultation and palpation. Aneurism of the vertebral artery may be mistaken for that of the common carotid. Compression of the latter against the transverse process of the sixth cervical vertebra will aid in the differentiation. The carotid artery has been erroneously ligated for vertebral aneurism (G. Fischer).

In the **treatment** of aneurism of the lateral cervical region reliance must be placed on ligation in continuity, for only by means of this operative procedure can a cure be hoped for.

The rare occurrence of a communication between the common carotid artery and the internal jugular vein is to be here noted.

Tumors of Lymphatic Origin.—Simple chronic as well as **tuberculous lymphadenitis** gives rise to inflammatory enlargement of the lymphatic glands of the neck, the latter attaining the size of the fist or becoming even larger. The superficial cervical glands may be affected, viz., (1) the **submaxillary,** situated beneath the body of the lower jaw in the submaxillary triangle and closely adherent to the submaxillary salivary gland; (2) the **suprahyoid,** situated in the middle line of the neck on the mylohyoid muscle and between the anterior bellies of the two digastric muscles; (3) the **lateral cervical,** placed in the course of the external jugular vein between the platysma and the deep fascia Involvement of the deep cervical glands includes (1) the chain beneath the sternomastoid and on its anterior edge, and intimately attached to the sheath of the carotid artery and the internal jugular vein above the bifurcation of the former, the **upper deep cervical** or **supracarotid glands;** (2) the **lower deep cervical glands,** clustered around the lower part of the internal jugular vein and extending to the supraclavicular fossa; (3) the **supraclavicular group.** The latter is continuous externally with the axillary and internally with the mediastinal glands. In addition to these, the **occipital** glands, which lie between the superior posterior edge of the sternomastoid and the trapezius, and the **posterior auricular group** may be involved. Finally, a **prevertebral group,** situated at the anterior surface of the cervical vertebrae, and an **internal carotid** group, extending along the internal carotid artery to the base of the skull, may be included in the classification, though these are usually inaccessible operatively.

These same glandular groups may be the seat of infection from primary carcinoma with resulting secondary **carcinomatous infiltration,** or simple inflammatory enlargement may result from the ulcerative changes occurring in malignant disease within the area of communication of the respective groups. It is best, however, not to trust to the latter possibility, but to regard all glandular enlargements in the neighborhood of cancerous disease as being essentially malignant in character.

The following table shows the relation of the respective groups of glands to the periphery (Treves):

Region.		
Scalp	Posterior part.	Suboccipital and mastoid (posterior auricular) glands.
	Frontal and parietal portions.	Parotid lymphatic glands; superficial cervical glands.
Skin of face and neck.		Submaxillary, parotid, and superficial cervical glands.
External ear.		Superficial cervical glands.
Lower lip.		Submaxillary and superficial cervical glands.
Buccal cavity.		Submaxillary and upper set of deep cervical glands.
Gums of lower jaw.		Submaxillary glands.
Tongue	Anterior portion.	Suprahyoid and submaxillary glands.
	Posterior portion.	Upper set of deep cervical glands.
Tonsils and palate.		Upper set of deep cervical glands
Pharynx	Upper part	Parotid and retropharyngeal glands..
	Lower part.	Upper set of deep cervical glands.
Larynx, orbit, and roof of mouth.		Upper set of deep cervical glands.
Nasal fossa.		Retropharyngeal glands; upper set of deep cervical glands. Some lymphatic vessels from the posterior part of the fossa enter the parotid lymphatic glands.

True **lymphomas** form a part of the disease known as **leukemia** (lymphatic leukemia), an affection belonging to the domain of internal medicine. The disease is characterized by the presence of tumors varying in size and occurring simultaneously in the cervical, axillary, and inguinal regions. These tumors differ from the enlarged glands resulting from tuberculous infection by being softer; the separate glands in lymphatic leukemia may also be isolated, whereas, in tuberculous lymphadenitis, the glands are massed together by inflammatory condensation and infiltration of the periglandular connective tissue. Microscopic examination of the blood will assist in the diagnosis, though the proportion of white blood-corpuscles is sometimes increased in general tuberculous lymphadenitis.

Sarcoma of the cervical glands is almost without exception a primary manifestation. These growths occur particularly in the upper deep cervical group, attain a large size, and destroy life either by compression of the trachea or by paralysis of the pneumogastric nerve. The large vessels of the neck are greatly distorted. Sarcoma may also occur in this region, having its origin in the connective tissue surrounding the vessels and muscles. **Extirpation,** unless attempted early in the case, is usually impracticable. Therefore treatment by means of **injections of sterilized cultures of the Streptococcus erysipelatis and the Bacillus prodigiosus** (Bruns, Coley) is to be attempted (see page 226).

Ligation of the Common Carotid Artery.—Indications.—(1) Hemorrhage; (2) aneurism; (3) operation on tumors; (4) neuralgia of the trigeminus (G. Fischer); (5) aneurism of the innominate artery (Brasdor's operation). In cases of hemorrhage the ligation may be either preventive or curative. In operative attacks on tumors the ligation may be either temporary and provisional or permanent. It has been suggested to ligate the common carotid artery in neuralgia of the trigeminus with the hope of benefiting the disease through the central nutritive changes that follow.

The **mortality** following the operation varies with the conditions present. When the vessel itself is healthy and no serious affection is present, as, for instance, when the operation is performed for neuralgia of the fifth nerve, the mortality amounts to 5 per cent. The mortality of all cases of ligation of the vessel is about 40 per cent. Both common carotids have been ligated successively (32 cases). In one case an interval of five years elapsed between the operations. In this case the patient lived forty-six years, and at the post-mortem it was found that the collateral circulation was carried on more by the ascending cervicals than by the vertebrals (Roth). The most successful cases are those in which several weeks intervened between the operations. In one instance, both carotids were ligated simultaneously (Valentine Mott). The attempt proved unsuccessful.

Functional disturbances are present, as a rule, even in one-sided ligation, when the collateral circulation is established and recovery takes place. These include mental impairment and paralysis of the peripheral nerve distribution. In fatal cases due directly to the ligation foci of cerebral softening are found. In double ligation these disturbances are most marked.

The Operation.—The point of election is at the level of the cricoid cartilage and above the omohyoid muscle. Below this, the vessel is comparatively inaccessible, and above it, the bifurcation is encroached upon. The patient

is placed on his back, the shoulders supported on a hard pillow, the chin drawn up, and the head turned slightly toward the opposite side (Fig. 374). The

Fig. 374.—"Dissecting Room Position" for Operations on the Neck.

position of the cricoid cartilage is ascertained and a three-inch incision made in the line of the artery with the center on a level with the cartilage. The skin

Fig. 375.—1, Ligation of the Common Carotid Artery above Omohyoid; 2, Ligation of Subclavian Artery.

and platysma are incised, the deep fascia divided along the anterior edge of the sternomastoid, and the latter followed until the omohyoid muscle is made out.

The superior border of the omohyoid muscle is then well exposed and identified. The sternomastoid is retracted outward and the omohyoid downward (Fig. 375). The carotid tubercle is now sought for and the vessel detected by its pulsation. The sheath of the vessel is opened on the side toward the median line, the descendens noni nerve avoided, and the vessel cleared from the sheath on the inner side first, the edge of the incision in the sheath being steadied with strong forceps. The outer side is then freed. For releasing the artery from the sheath a curved blunt instrument, such as an unthreaded aneurism needle, is to be employed. It is important that the process of clearing the artery from the sheath should be carried out with great care and that it should be thoroughly done. The ligature should be passed from without inward. The descendens noni

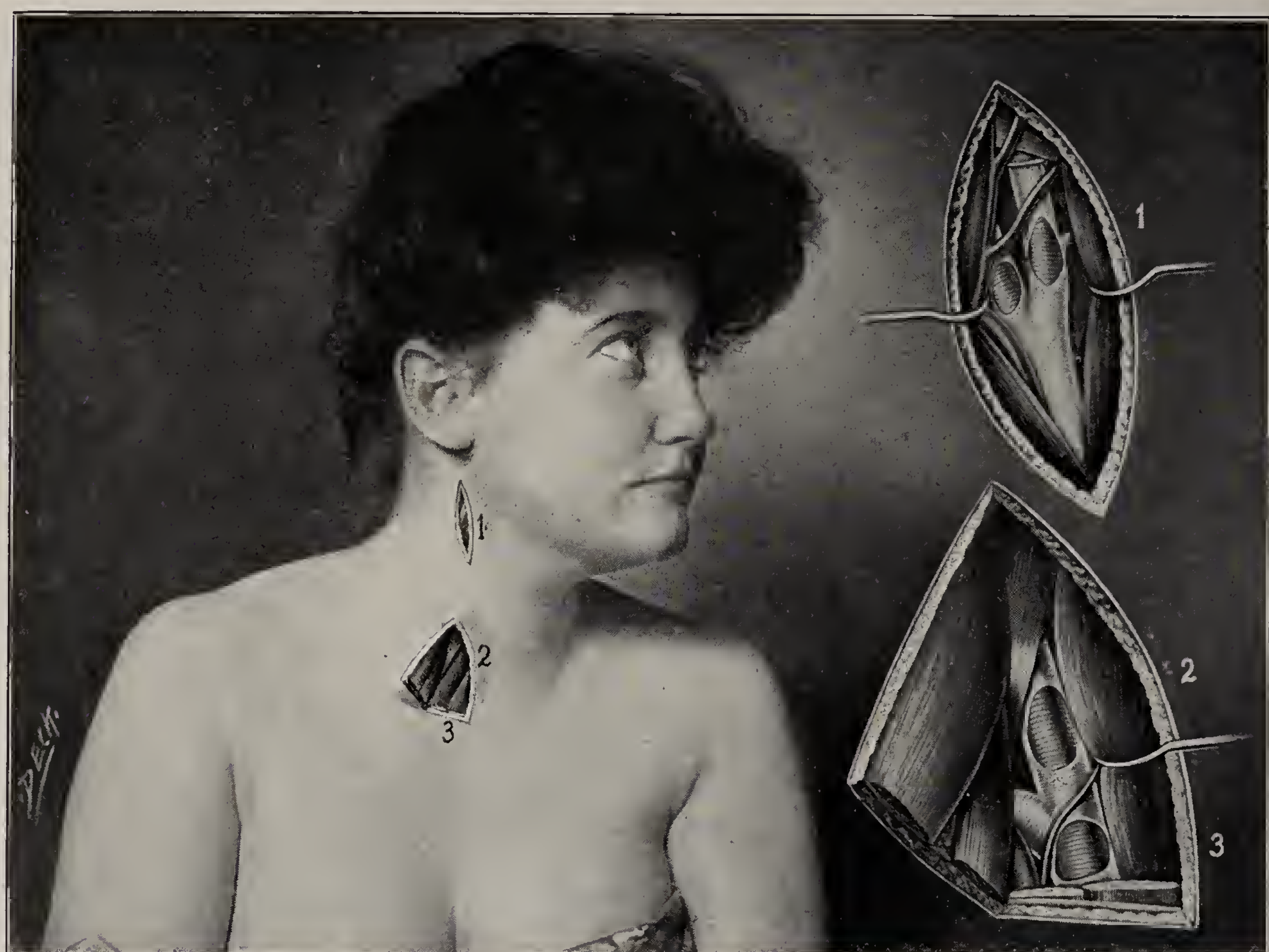


Fig. 376.—1, Ligation of the Internal and External Carotid; 2, Ligation of the Common Carotid below the Omohyoid; 3, Ligation of the Innominate.

The sternomastoid is here shown divided. This is not always necessary, but if ready access is not obtained, both this and the sternothyroid and sternohyoid may be cut.

nerve and the pneumogastric have been accidentally included in the ligature, and the artery has been transfixed by clumsy manipulation.

Ligation of the External and Internal Carotid Arteries.—Ligation of the external carotid artery for aneurism is less frequently indicated than ligation of the common carotid. Hemorrhage from the branches of this vessel can be generally controlled by ligation at the point of injury. Bleeding from the internal maxillary and its branches may, however, indicate ligation in continuity of the external carotid. The collateral circulation is very quickly reestablished by the free communication of its branches (facial, lingual, superior thyroid, and occipital) with the corresponding arteries of the opposite side, as well as with branches of the internal carotid, particularly the ophthalmic

Ligation of the external carotid is most frequently performed in the course of operations for the removal of deeply placed tumors.

I have found **preliminary ligation** of the vessel beyond the facial and occipital branches of advantage in controlling the hemorrhage from the middle meningeal branch in intracranial neurectomy of the trigeminus in intractable neuralgia (see page 541).

Operation.—A line drawn from the external auditory meatus to the side of the cricoid cartilage marks the line of the artery with sufficient accuracy. An incision two and a half inches in length is made on this line, with its center resting on the greater cornu of the hyoid bone. The vessel is reached by baring the anterior edge of the sternomastoid muscle, retracting the latter outward, identifying the greater cornu of the hyoid bone, and after the posterior belly of the digastric at the upper angle of the wound and the hypoglossal nerve at the lower angle are located, by exposing the artery between the origins of its superior thyroid and lingual branches. After the artery is cleared the aneurism needle is passed from within outward, care being taken to avoid the superior laryngeal nerve, which curves behind the artery at this point. In order to minimize the risks of secondary hemorrhage it has been advised to secure the superior thyroid, lingual, and ascending pharyngeal branches (Jacobson). This, however, is usually very difficult; moreover, as has been shown (Harrison Cripps), the fear of secondary hemorrhage is not well founded.

The **internal carotid artery** very rarely requires ligation. Hemorrhage from the vessel in the carotid canal, erosion of the vessel from disease of the bone, wounds of the vessel (Lee), and traumatic aneurism (Briggs) constitute the principal indications. The vessel has also been tied for secondary hemorrhage following removal of the lower jaw (Sands). The collateral circulation is almost immediately restored through the branches of the vessel of the opposite side in the circle of Willis and the vertebrals. The common carotid has been ligated by mistake for the internal carotid (Broca).

Operation.—The line of the artery is practically the same as that of the external carotid. The latter vessel is first exposed and then drawn inward with a small blunt hook. The digastric muscle is drawn upward, when the internal carotid is brought into view. The latter vessel is secured at its commencement close to the bifurcation. The needle is passed from without inward, and the same care is taken to avoid injury to the internal jugular vein and the pneumogastric nerve as in ligation of the common carotid.

Ligation of the Innominate Artery.—The only indication for ligation of the innominate artery is aneurism of this vessel at the point of its division into the right common carotid. The operation was first performed by Valentine Mott, of New York, in 1818. Though aneurism of this vessel is not rare, in a large proportion of cases the diseased condition occupies the entire area of the artery. Among the 24 reported cases (Ashhurst) but one proved successful, that of Smith, of New Orleans (1864). Mitchel Banks's case survived fifteen weeks. Death takes place from secondary hemorrhage from the peripheral end, the powerful collateral circulation through the common carotid, subclavian, and vertebral preventing the formation of a firm clot (Le Fort). In Smith's case this also occurred, though the right common carotid was simultaneously ligated. The patient was saved by prompt

ligation of the vertebral artery. In future cases the aseptic procedure may obviate this danger. The operation is very difficult of performance.

Operation.—The skin incision commences at the left sternoclavicular articulation, and follows, with a slight curve downward, the upper edge of the sternum until the right sternoclavicular articulation is reached. This is met by a vertical incision three inches long which follows the anterior edge of the sternomastoid muscle. The superficial fascia is divided in the same lines. The flap is dissected up and the sternohyoid and sternothyroid muscles divided close to the sternum. In order to gain more room the sternomastoid may be partly divided, care being taken to avoid injuring the anterior jugular vein. If met, it is to be divided between two ligatures.

The deep cervical fascia is now incised in the direction of the original wound and the common carotid sought for and its sheath opened as low down as possible. This vessel is now traced downward until the bifurcation of the innominate is reached. The vessel usually lies behind the right sternoclavicular articulation, in the mass of fat and connective tissue extending downward to the anterior mediastinum and upward to the trachea and esophagus. In following the artery downward, when it is situated low down, the head should be slightly flexed and the search aided by a head-band reflector (Jacobson). The innominate vein and pneumogastric nerve should be drawn outward and injury to the pleura avoided by keeping the needle closely applied to the artery. The needle is to be passed from without inward and slightly from above downward. Special difficulties are met when the parts surrounding the vessel are matted together by adhesions. The operation may have to be abandoned on account of extensive disease of the artery, in which case Brasdor's operation of ligation of the right common carotid and subclavian should be substituted.

In order to avoid secondary hemorrhage, the common carotid and vertebral should be ligated at the same time. Sterilized floss silk or chromicized catgut should be employed as ligature material.

Ligation of the Subclavian Artery.—Ligation of this vessel may be demanded by certain injuries and diseases of the upper extremity, tumors of the axilla and operations for their removal, and by hemorrhage. The vessel has also been ligated in cases in which distal ligation is employed in innominate and aortic aneurism, as a preliminary step in excision of the scapula, and in amputation of the entire upper extremity. The mortality is almost 50 per cent (W. Koch). Though the cause of death in most of the fatal cases has been due to the condition for which the ligature was applied, yet the ligation itself is not without danger. In case the wound suppurates, suppurative pleuritis may cause death. The pleura may be injured and pneumothorax result.

The vessel may be exposed and secured in its second portion, where it lies behind the scalenus anticus; in its third portion between the external edge of the scalenus anticus and the outer border of the first rib; and, finally, below the clavicle at the upper portion of the anterior thoracic wall. The first-named situation is very unfavorable on account of the proximity of numerous and large branches (vertebral, internal mammary, thyroid axis, and the superior intercostal), the necessity for division of the scalenus anticus muscle and the consequent risks of injuring the phrenic nerve and the internal jugular

vein, and the dangers of injury to the pleura, with which the artery is in contact below. The third part is the most favorable point for application of the ligature. Here the artery is more superficial and does not send off any branches; as far as present surgical experience extends, it is the only justifiable point to apply a ligature except when the operation is performed in cases of tumors of the axilla (secondary carcinomatous deposits involving the vessel and demanding its resection). This artery was first successfully ligated by Post, of New York (1817).

Operation.—The patient's head is turned toward the opposite shoulder and the neck is slightly flexed laterally. The corresponding arm is drawn downward and the shoulder depressed. The skin of the posterior triangle of the neck is drawn downward and an incision three inches in length is made through the skin and platysma down on the clavicle. The external jugular vein is avoided by this maneuver. When the traction is withdrawn, this incision should extend from the trapezius to the sternomastoid. To this may be added a short vertical incision. The deep cervical fascia is now incised in the length of the original wound. If the external jugular vein comes into view, it is to be displaced outward and divided between two ligatures. The omohyoid muscle is retracted upward and outward. The edge of the scalenus anticus muscle is now sought for and the finger passed along its edge until the tubercle of the first rib is identified. The brachial plexus is identified with the finger as it passes from above downward and outward, limiting the supraclavicular fossa above. The vessel itself is identified by its pulsation as it rests on the bone. The artery is now cleared by careful dissection and an unthreaded aneurism needle passed from above downward and from behind forward. The index-finger serves as a guide for the passage of the needle and at the same time protects the vein from injury. Care is necessary not to wound the pleura. The needle is now threaded and withdrawn.

The **vertebral artery** is accessible for about an inch and a quarter of its length. It can be reached only just below the transverse process of the sixth cervical vertebra and before it enters the canal of this process. It was first tied by Maisonneuve (1852). The first successful case is that of Smith, of New Orleans (*vide supra*). Alexander, of Liverpool, ligated the vertebral in 36 cases of epilepsy. Of these, 33 recovered from the operation. The strong collateral current from the vessel of the opposite side through the basilar artery usually renders the operation useless. The artery is reached by an incision three inches in length, commencing at the clavicle and extending along the posterior border of the sternomastoid. The transverse process of the sixth cervical vertebra is the guide to the vessel. It is usually necessary to divide a portion of the clavicular attachment of the sternomastoid. The vertebral vein lies in front of the artery. On the left side the thoracic duct may be endangered.

Stretching of the Brachial Plexus.—For intractable neuralgia of the arm the brachial plexus has been stretched at the points where its roots leave the intervertebral canals. The incision begins at the middle of the sternomastoid, extends downward for about two inches, and terminates about an inch and a half from the posterior edge of the latter muscle. The external jugular vein is to be compressed above the clavicle by an assistant. The transversalis colli crosses the plexus horizontally in the lower third of the

wound. The plexus is lifted by means of a blunt hook and freed by the index-finger, isolated, and stretched in both directions.

Stretching of the cervical plexus is indicated in neuralgia in the occipital, auricular, and supraclavicular regions. Branches of the cervical plexus may be reached by an incision along the posterior edge of the sternomastoid; from the middle of this muscle upward the branches are followed behind the muscle to their points of origin from the plexus. Great care is necessary to avoid injury to the internal jugular vein.

Intraspinal Nerve Stretching and Neurectomy.—The **posterior or sensory roots** of spinal nerves have been stretched, as well as divided and resected, for persistent neuralgia (Dana, Abbe, 1888). Portions of the arches of the vertebrae are removed and the dura exposed for two inches. The latter is not opened. The intervertebral foramina are explored by a curved blunt hook and the nerves stretched, divided, or resected. The results of the operation thus far have not been very satisfactory.

Neurectomy of the Spinal Accessory Nerve.—Clonic spasm in the area of distribution of the **spinal accessory** has been treated by neurectomy of this nerve. The point where the nerve passes into the sternomastoid corresponds to almost the exact middle of this muscle (*i. e.*, half-way between the mastoid process and the inner extremity of the clavicle). The posterior edge of the muscle is exposed and the nerve sought for at the point where it passes from within outward to the sternomastoid and thence to the trapezius. The nerve is resected here without difficulty. The results of the operation have thus far been satisfactory.

Operations for the Removal of Tumors of the Neck.—The extirpation of **tuberculous lymphatic glands** is indicated for the prevention of general tuberculosis. Early operation is preferable, not only because of the greater protection afforded but on account of ease of performance as well. In late cases the glands become attached to important surrounding parts. Curved incisions should be employed, wherever practicable, a flap being turned back to give access to the underlying parts and the glands isolated with the thin wedge-shaped handle of the scalpel, rather than with its blade. The closed blades of a curved blunt scissors will be found very useful.

The suprahyoid group is removed without difficulty. The only vessel requiring ligation is the small mylohyoid artery. The submaxillary lymphatic glands are more difficult of extirpation. The facial artery is frequently injured. This group may extend downward to the lingual artery and outward to the external carotid. The submaxillary salivary gland is frequently involved in the mass and is removed as well.

Extirpation of the upper deep cervical or supracarotid group is still more difficult. Fortunately, in most cases the connective tissue is not very intimately adherent at the posterior aspect of the group or in the direction of the vessels. Ligation of the common carotid artery is seldom necessary, though its wall is frequently exposed. The edge of the knife should never be directed toward the vessels.

The **lower deep cervical glands** are exceptionally difficult of removal by reason of their intimate relation with the internal jugular vein and their frequent adhesions to it. The portion involved in the latter is to be left till the

last; then, if the vein is injured, the wound in the latter can be grasped by hemostatic forceps and a **lateral ligature** applied.

The **occipital and supraclavicular** groups are usually easy of extirpation. Glands lying on the internal carotid artery and those constituting the prevertebral group are exceedingly difficult of removal, and the impossibility of reaching all of the diseased glandular structures nullifies the entire operation.

In case these glands have suppurated, complete removal may be impossible. Under these circumstances the abscess cavity is to be evacuated and its walls curetted, vigorously rubbed with iodoform gauze, and only partially closed.

Carcinoma and Sarcoma.—The justifiability of removal of malignant tumors of the neck will depend on whether or not they are movable on the underlying parts. The absence of mobility on the vertebral column, or only a slight mobility, as a rule is a contraindication to extirpation. Their size and location must also enter into the question.

Before exposing the growth it is not always possible to decide as to the practicability of removal. Sometimes the tumor is not attached to the carotids, but only lies against them or the internal jugular vein. Where the vessels are displaced by the growth, they will often be found intimately adherent to it. In case of doubt the operation should always begin by exposing the common carotid artery below the tumor and passing a provisional ligature around the vessel. By adopting this precaution excessive hemorrhage may be prevented.

When portions of the carotid artery or the internal jugular vein are involved in the growth and require removal, this must be accomplished between two ligatures. When the vein is accidentally wounded low down, instant digital compression must be made to prevent entrance of air. The bleeding point is then to be grasped beneath the compressing finger by broad-bladed hemostatic forceps, and the vessel secured by a ligature. It is still an open question as to whether or not the operation is to be abandoned when the pneumogastric is involved. Instances of complete division of this nerve are recorded in which the patient survived. If the operation is to be proceeded with, no portion of the tumor is to be left behind. The necessity for abandoning the operation before completion is always an unfortunate circumstance, for the reason that septic conditions usually supervene and rapid growth of the remaining portion always occurs. The removal of a growth that has begun to break down should not be undertaken. The inevitably fatal result may sometimes be postponed, however, by removing septic foci with the sharp spoon and packing with iodoform or other antiseptic gauze.

Even after apparent complete extirpation and perfect healing recurrence is the rule and immunity the exception.

Branchial Fistula.—Congenital fistulas of the neck result from incomplete closure of the branchial clefts (see page 237). In the great majority of cases they arise from the fourth branchial cleft, in which case the external opening is situated just above the sternoclavicular articulation, and on either the outer or the inner edge of the sternal portion of the sternomastoid muscle. When they arise from the upper clefts, the external opening is found on a level with either the cricoid cartilage or the thyroid cartilage and at the inner edge of the sternomastoid. When found high up, congenital ear fistulas (Hensinger) or atresia of the external auditory canal, as well as malformations of the external ear, may coexist (Virchow).

In about one-third of the cases the fistula is double-sided. In the one-sided cases it is most frequently found on the right side. It may be complete or incomplete. The fistulous canal is lined with mucous membrane; its external opening is usually very small and is marked by a slight elevation or a reddish ring of mucous membrane. The secretion from the canal may amount to only a slight moisture; generally there is a scanty, stringy, saliva-like fluid, which, under some circumstances, may become purulent. Fetal cartilage may be found in the depths of the fistula.

When the fistula is complete, it leads under the skin in the direction of the greater cornu of the hyoid bone, and thence beneath the lower margin of the inferior maxilla to open in the pharynx in the neighborhood of the tonsil. The canal is wider than either of its openings and a dilated portion is sometimes found near the external opening. When incomplete, it ends blindly a short distance above the aperture, and from retention of secretion it may lead to the formation of a small cyst.

Females are affected oftener than males. Hereditary influences are sometimes observed. Ascherson records eight cases occurring in three generations of one and the same family.

The **treatment** of complete fistula is very unsatisfactory, owing to the difficulty of destroying the mucous lining. Cauterization, as well as the injection of iodin, gives but indifferent results. Excision of the fistulous track is usually impracticable, and if successful leaves an amount of scarring as objectionable as the fistula itself. Incomplete and shallow fistulas may be dissected out without difficulty.

Cervical Sympathectomy.—This operation has been recommended for glaucoma and for Jacksonian epilepsy (Alexander; Jonnescu). The incision is the same as for ligation of the carotid artery.*

The **superior ganglion** is first sought. The internal jugular vein, pneumogastric nerve, and internal carotid artery are identified in turn and drawn anteriorly; the sternomastoid is retracted posteriorly. The cervical sympathetic cord is differentiated from the pneumogastric and superior laryngeal nerves, and traced upward until the lower border of the ganglion is reached. This appears as a reddish-gray fusiform swelling on the cord about 3 centimeters in length, lying posteriorly to the commencement of the internal carotid and on the rectus capitis anticus major muscle. The ganglion is carefully cleared and secured by catch forceps, and slow and careful traction is made until its upper border appears, when the cord above is severed. Sometimes the cord and ganglion come away by avulsion.

The cord is now traced downward until the **middle ganglion** is reached. This is situated opposite Chassaignac's tubercle in front of or on the inferior thyroid branch of the subclavian and about on a level with the omohyoid muscle. The ganglion is detached from its cardiac filaments and the cord below the ganglion traced downward.

The **inferior ganglion** is in relation to the superior intercostal branch of the subclavian artery, and in order to reach it with safety the skin incision is extended and the artery exposed in its first portion. On the left side the ganglion

*Braun, of Göttingen, operated by an incision placed posterior to the sternomastoid. He found difficulty in locating the upper ganglion, and, because of the difficulties and dangers, abandoned the attempt to remove the lower ganglion.

lies behind the subclavian and on the inner side of the intercostal artery. On the right side the artery is behind the muscle, and the ganglion is in relation with the inner edge of the latter, and lies between the base of the transverse process of the last cervical vertebra and the neck of the first rib. Here the greatest care is required to avoid injury to the vessels and to the phrenic nerve as it passes in front of the subclavian to the inner side of the scalenus anticus. Once the ganglion is identified it is forced upward by gentle traction and separated from the cord below by avulsion.

In case the operator succeeds in identifying the ganglion readily on the first side attacked, both sides may be operated on at the same sitting. Visual disturbances due to interference with the sympathetic supply to the ciliary muscle are more or less pronounced and in some instances irremediable and permanent.

In four cases in which I operated for epilepsy all recovered from the operation. In the first case the patient died in the **status epilepticus** before the second operation could be performed. In the other three cases both sides were operated on at the same sitting. In the first of these no benefit was derived. In the second the patient, an exceedingly sensitive youth, was cured, but he committed suicide in the following year in a fit of mental despondency incident to erratic and intractable visual disturbances following the operation. The fourth case could not be traced beyond three months after the operation, up to which time he had had no return of the convulsions.

THE CERVICAL VERTEBRAE

Injuries of the spine in general, like those of the skull, derive most of their importance from the associated injury of the contained nerve centers and trunks. In addition to this, the function of the spine as a support to the head is interfered with.

Fracture of the Cervical Vertebrae.—The body of the vertebra is broken in a little more than one-half of the cases; in the remainder the arches are broken (Gurlt). Fracture of the arches is more frequent above the middle of the cervical region, and fracture of the bodies below this point. Simultaneous fractures of two or more vertebrae occur not infrequently. The axis is more frequently broken than the atlas, and the odontoid process is sometimes broken alone. The body of the axis is most frequently broken about a fourth of an inch below the neck of the process. Fractures of the spinous processes occur, particularly of the seventh.

In fracture below the fourth cervical vertebra the paralysis will usually affect both arms. The anesthesia may be asymmetric at first; the asymmetry, however, soon disappears as degenerative changes progress. A hyperesthetic area may be noted in the parts supplied from immediately above the injury on account of irritation of the latter. Owing to the length of the course of the involved nerves within the spinal canal, the area of both motor and sensory paralysis will be lower than the point of injury to the cord. A differential diagnosis of fracture and dislocation is frequently impossible.

In cases of **fracture of the odontoid process,** the head is held rigidly fixed, and, when accompanied by displacement, the larynx is unduly prominent; the voice sounds may be altered. The posterior wall of the pharynx may be pushed

forward by the displaced vertebra. Crepitus may be felt and pain and tenderness present in the occiput and neck.

Prognosis and Complications of Injuries of the Cervical Vertebrae.—Both fracture and dislocation of the bodies of the cervical vertebrae are necessarily attended by a high mortality, owing to the almost inevitably accompanying injury of the spinal cord and the consequent severe disturbance of function. These functional disturbances decrease somewhat in importance the lower down in the spinal column the injury occurs. They retain a very serious import, however, even low down in the lumbar region. Injuries below the fourth cervical vertebra may paralyze the respiratory muscles with the exception of the diaphragm (distribution of the phrenic nerve). Severe injury above the fourth vertebra may produce immediate death from complete paralysis of respiration. Even with preservation of the phrenic nerve death usually takes place in a few days, the patient dying of suffocation from final failure of the diaphragm to act. Injuries sufficiently low down to leave all the respiratory nerves intact are still usually followed by a fatal result from paralysis of the remaining motor nerves, as well as of the sensory nerves.

When the injury occurs above the fourth cervical vertebra and the cord is damaged, the injury may prove immediately fatal; or the patient may survive for a few hours, or, in the majority of cases, for a fortnight at the most. Exceptionally, patients may survive for a longer period (Shaw's case for fifteen months and Hilton's for fourteen years).

It is not possible to determine at the commencement whether or not laceration of the cord has taken place. In cases of contusion of the latter the paralysis may be complete at first, subsequently improving. Treatment should therefore be instituted in such cases and continued as long as the patient remains alive. Most frequently, however, the cord is lacerated, as revealed by the autopsy. Even when the cord escapes laceration, contusion of this structure, hemorrhage, and laceration of the roots of the spinal nerves lead to **inflammatory softening of the cord,** which finally extends to the uninjured portions. This is announced by a rise in temperature, which sometimes occurs suddenly; it is sometimes preceded by an abnormally low temperature.

Treatment of Fractures of the Cervical Vertebrae.—The spine should be gently straightened, the patient placed on a water-bed, and every precaution taken to prevent bedsores. The bladder should be emptied every six or eight hours. Where there is palpable deformity, attempts should be made at rectification. This should be attempted by extension and counter-extension, the patient lying on his back, and manipulation at the site of fracture. The chin and collar portion of Sayre's suspension apparatus may be used for extension, and counter-extension maintained by raising the head of the bed, a rubber sheet being used with boric acid sprinkled on it to prevent friction.

Resection of the spine, or **laminectomy,** has been frequently resorted to of late years, either as an immediate or as a secondary operation. Postmortem examinations have shown that even where the cord is not lacerated, pressure from displacement may produce irremediable softening in from twenty-four to forty-eight hours. The mortality after laminectomy is 48 per cent (White). The immediate operation is indicated particularly where fracture of the arches can be made out. The operation may still be of service when the body is broken and displaced, the compression being due to coincident displacement of

the laminae. When performed as a secondary operation, it is indicated by failure of improvement in the paralysis at the end of six weeks, with persistent spread of bedsores, incontinence of urine and cystitis (Lauenstein).

The **indications for operative interference** in injuries of the osseous framework of the spine are as follows: (1) in compound fractures for the removal of foreign bodies and fragments of bone; (2) in injuries of the arches and spinous processes, with lesions of the cord, when bony fragments are driven against the theca and are liable to produce further injury at every movement; (3) in the rare cases where the symptoms are mainly due to thecal or perithecal hemorrhage pressing upon the cord; (4) in pachymeningitis and perimeningitis following an injury; (5) in cases where the cauda equina is pressed upon, recovery may follow the relief of pressure by operation. (For the operation of laminectomy, see Vol. II, page 2.)

DISLOCATIONS OF THE CERVICAL VERTEBRAE

These are more frequent than fractures in the cervical region, on account of the greater flexibility of this portion of the spinal column. Combined dislocation and fracture occurs, however, the bony insertions of the strong ligamentous structures giving way. Under these circumstances the fracture is unimportant as compared with the dislocation.

Mechanism and Varieties of Dislocation.—With the exception of the movements of the atlas and axis, the movements of the cervical spine are comprised in those of **flexion** or bending forward, **extension** or bending backward, and **abduction** or lateral bending, the head approaching the shoulder. In the latter movement, when extreme, there is also flexion, these two movements combined comprising **rotation.**

Dislocation in Extension.—Extension movements are more limited than those of flexion, owing to the tilelike arrangement of the vertebral arches. Extreme extension to the point of dislocation, therefore, presupposes compression and final crushing of the arches, and after this, of the cord as well. Cases of this description are rarely seen clinically, death taking place almost immediately.

Flexion Dislocation.—In extreme flexion the arches are carried away from each other, the two articular processes of the upper vertebra moving upward on the two articular processes of the lower vertebra, being restrained only by tension of the ligamentum subflava. The posterior edge of the upper vertebral body is lifted away from the posterior edge of the one below. With the yielding of the ligaments between the arches and the posterior portion of the intervertebral disc, and, perhaps, the tearing away of the bone (avulsion), the articular processes of the upper vertebra leave those of the lower vertebra, and the former is **dislocated forward,** its articular processes resting in front of those of the lower. Reduction is then opposed because the articular processes of the upper vertebra become locked in front of those of the lower, from which position they must be released before both pairs of articular processes can be brought again into normal relations with each other.

Falls from a height, the patient striking on the head, and the falling of heavy masses of earth and the like on the head, are the most common **causes of flexion dislocations.** Many of these accidents are followed by instant death

from paralysis of respiration or prove fatal before surgical assistance can be summoned.

The **symptoms** of flexion dislocations are usually well marked and unmistakable, though transverse fracture of a cervical vertebra with anterior displacement may simulate flexion dislocation. The head is bent forward, the chin approaching the sternum. The neck muscles are spasmodically contracted and bulge on each side. There is a sudden interruption of the line of the spinous processes corresponding to the forward recession of the upper vertebra, and the spinous process of the latter cannot be felt. **Deglutition** is interfered with and the projecting body of the dislocated vertebra can be felt under the pharyngeal mucous membrane posteriorly. Paralysis to a greater or lesser extent is always present from encroachment upon the lumen of the spinal canal, this varying, however, both in degree and in extent.

Finally, cases occur in which **recoil** takes place. In the cervical region these are believed to be commoner than cases of persistent displacement (Thorburn). The injury to the cord may be quite as great as when permanent displacement is present.

The **treatment** consists in an immediate attempt at reduction, the risks of the procedure having been previously explained to the patient or his friends, as well as the further fact that even should reduction be successful a fatal result may yet occur from damage already inflicted on the cord. Simple traction in the longitudinal axis is successful in many cases, all the ligaments being torn. This latter, however, makes traction all the more dangerous, slight overtraction resulting in complete separation of the already injured cord. Converting the flexion dislocation into a rotation dislocation and then reducing this (Hueter) is effected as follows: The head is carried strongly toward one shoulder, and by rotating movements the opposite articular process is disentangled from its locked position with that of the one below and replaced in its normal relation with the latter. The head is now abducted in the opposite direction and the same maneuver repeated, the other articular process being dislodged and finally reduced.

Rotation Dislocation.—With combinations of flexion and abduction, the articular process of the upper vertebra may rest in front of the corresponding articular process below on the side toward which abduction is made, while the other two articular processes bear their normal relation to each other. Under these circumstances a rotation dislocation is said to have occurred.

This form of dislocation is most commonly produced by a fall on the head, the weight of the trunk falling to either one side or the other and bending to the corresponding side the cervical portion of the spinal column. The dislocation usually occurs either between the fourth and the fifth vertebra or between the fifth and the sixth vertebra.

The **symptoms** are not so marked as in flexion dislocation. The head is inclined to one side toward the shoulder. The neck muscles corresponding to the side on which the dislocation has occurred are somewhat prominent. The chin is not markedly rotated toward the opposite side, as in active or physiologic abduction of the head. In thin persons the slight displacement may be felt on palpation. A prominence, more marked on one side than on the other, can be felt on the posterior pharyngeal wall. **Paralytic symptoms** are not so prominent in this dislocation as in that last described. In most

instances, however, the roots of the spinal nerves at this part, particularly those of the brachial plexus, are more or less contused, and pain in the distribution of these, together with formication and paretic conditions, is present. Hemorrhage, compression, or concussion of the cord may likewise occur, though rarely.

The **treatment** consists in immediate reduction, not only to correct the position of the head, but to restore the function of the nerves distributed to the arm and to avert progressive disturbances in the cord itself. Reduction by traction is positively contraindicated. The dislocation must be reduced in the way it occurred. The position of superabduction is the cause of the hooking of one articular process in front of the other, and the head must be brought back in this position. The manipulation consists in first forcing the head in a further position of abduction, or toward the side to which it already tends; this releases the articular process. The head is then rotated so that the ear of the same side moves toward the front, the ear of the opposite side moving backward.

In the **after-treatment** of dislocations of the cervical vertebrae the head must be secured in the median position. In cases of rotation dislocation a simple pasteboard cravat answers the purpose. In cases of flexion dislocation the destruction of the ligamentous apparatus demands more trustworthy means. Here the plaster-of-Paris bandage is to be added, which should encase both shoulders as well. The patient should be placed on a water-bed to prevent bedsores and the results of the paralysis treated symptomatically.

The Atlas and Axis.—These occupy a special position, both anatomically and clinically. Flexion and extension are accomplished through the atloido-occipital articulation and rotation through the atlo-axoid articulation. These are protected by very strong ligaments, which, when ruptured, permit dislocation, with resulting pressure on the spinal cord and instant death. This occurs in official hangings, in which the body, falling from a sufficient height, is suddenly arrested by the rope encircling the neck. The ligament behind the odontoid process gives way and the cord is crushed by the backward movement of the process. Fractures of the atlas and axis are specially dangerous from proximity of the medulla oblongata.

In **suicidal hanging** in the majority of cases the rope slides upward and constricts the pharynx, as well as the large venous trunks, carotid artery, and pneumogastric nerve. Neither the spinal cord nor the vertebrae are injured.

Dislocations of the odontoid process sometimes occur with fatal results from lifting children by the head in play. Dislocations between the atlas and the axis are rare (8 out of 73 cases of dislocations of the cervical vertebrae, Blasius). **Fracture of the odontoid process** is somewhat rare; the process is more resistant than the arch and the transverse ligament which secures it (Stephen Smith). The accident is almost necessarily fatal.

INFLAMMATORY AFFECTIONS OF THE CERVICAL VERTEBRAL COLUMN

Practically, these may be divided into those which affect the articulations of the oblique or articular processes, and those which affect the body of the vertebrae.

Inflammation of the Lateral Articulations.—This is usually of rheumatic origin. The inflammation rarely passes beyond the stage of serous

effusion. It occurs more frequently in children than in adults. Pain is referred to the region of the articular processes and is always unilateral. Tenderness is present. The head is abducted toward the diseased side (**inflammatory torticollis**), in order to relax the synovial membrane.

The **treatment** consists in the application of warm moist compresses. Later, a pasteboard and starch bandage dressing to restrict movements and gradually restore the head to its normal position is applied. In chronic cases the application of the actual cautery (thermocautery) may be of service. It may be necessary to employ forced passive motion later on, if adhesions restrict the movements of the head. The prognosis is usually good, though moderate wryneck or **caput obstipum** has resulted from the affection.

Spondylitis in the Cervical Region.—Inflammation of the bodies of the cervical vertebrae belongs to the large group of affections known as Pott's disease. The intervertebral discs take only a small part in the affection. The disease is essentially a granular (tuberculous) myelitis of the vertebral bodies, including the cancelli, the cortical lamellae, and finally the periosteum and the surrounding tissues. Abscess forms in the vertebral body and the pus makes its way in various directions (**migratory abscess**).

The inflammation is almost exclusively of infectious origin, the bacillus being deposited by the blood in the abundant medullary tissue of the growing bone; hence its more frequent occurrence in childhood. The middle portion of the cervical column is attacked with greatest frequency, as a rule, though opinions differ on this point. Taylor asserts that the sixth and seventh cervical vertebrae are more liable to the disease than all the other vertebrae of the spinal column.

Kyphosis or permanent curvature occurs here as in other portions of the spine attacked, and is due to the fact that the vertebral body, after condensation of the cancellous and cortical substance, sinks anteriorly under the influence of the weight of the head. The curve is more uniform and convex than in kyphosis in the dorsal and lumbar regions, owing to the normal curve of the neck, which, being placed with its concave surface directed anteriorly, constitutes a **lordosis. Scoliosis,** or lateral curvature, is rare in the cervical region, unless the focus of the disease occupies but one-half of the vertebral body. Under these circumstances a variety of inflammatory **caput obstipum** is present.

The spinal cord escapes injury from the fact that the disease tends to extend anteriorly rather than toward the vertebral canal. Resulting abscesses also incline to pass anteriorly; exceptionally, however, they may follow the root of one or the other lamina or arch and progress laterally, in which case they may follow the roots of the brachial plexus and point in the supraclavicular region, or even in the axilla. When pointing anteriorly from the lower cervical vertebrae they find their way into the posterior mediastinum and thence into the pleura, or into a bronchus, causing death. From the middle cervical region they reach the posterior pharyngeal wall, forming a **retropharyngeal abscess.** With the exception of the rather rare form of the latter resulting from phlegmonous inflammation of the submucous tissue, or suppurating lymphadenitis of a retropharyngeal lymphatic gland, retropharyngeal abscess arises almost exclusively from Pott's disease in the cervical region. The projection of the abscess into the cavity of the pharynx produces disturbances of deglutition at first, and finally disturbances of respiration.

Treatment.—The abscess should be emptied early. This may be done through a small incision, in order to avoid entrance of pus into the glottic opening, or the abscess may be incised freely with the head in the dependent head position of Rose (see page 534). The walls of the abscess contain the constrictor muscles of the pharynx; hence, their elasticity is such as to lead to rapid emptying and collapse. This favors early resolution, the healing process frequently being completed in a remarkably short space of time.

In the further treatment of Pott's disease in the cervical region it will be necessary to apply some form of support for the head and vertebral column.

Fig. 377.—Jury Mast.

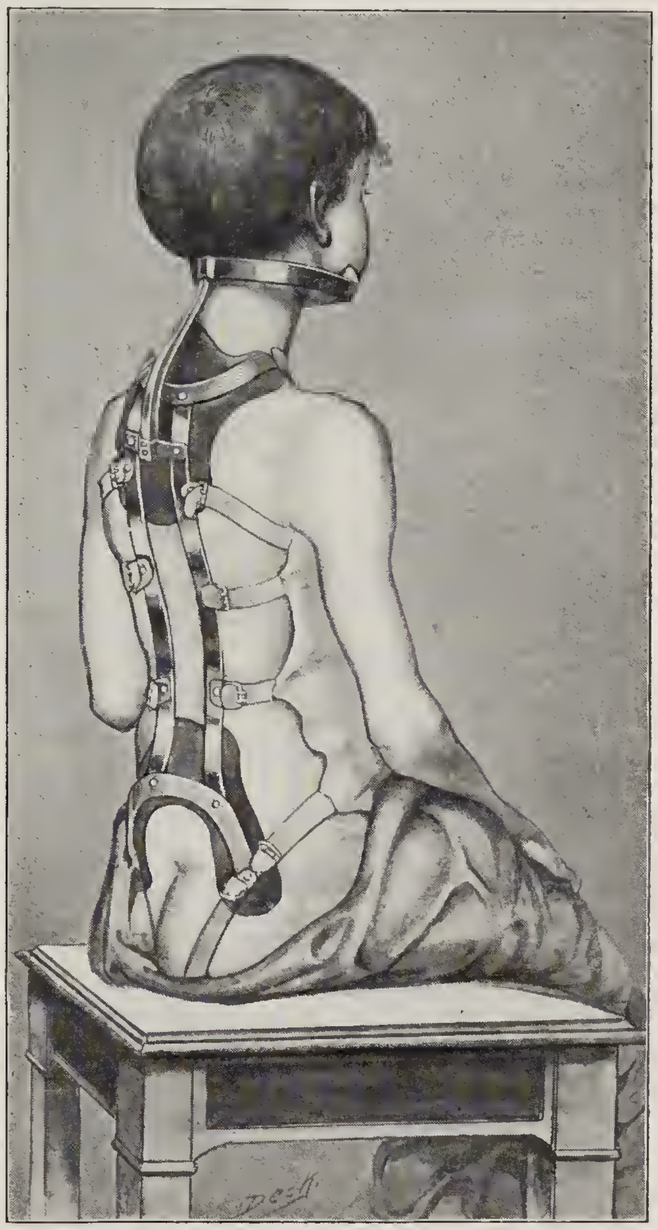


Fig. 378.—Anteroposterior Support with Head-piece.

This may be accomplished by the use of a jury mast attached to a plaster-of-Paris jacket (Fig. 377), by an anteroposterior support with head-piece (Taylor, Fig. 378), by a padded leather collar (Thomas, Fig. 379), or by a brass wire collar (Burrell, Fig. 380). The two latter are rendered more efficient by being attached to an anterolateral support. Or Volkmann's method of extension in the recumbent position may be employed (Fig. 381).

Caries sicca of the medullary structure of the atlas and axis, particularly of the latter, may occur. The inflammation soon attacks the neighboring joints and synovitis ensues. The affection is more common in adults and in old

people than in children. Caries with suppuration is uncommon in this region, even in cases where the autopsy reveals extensive destruction of osseous and

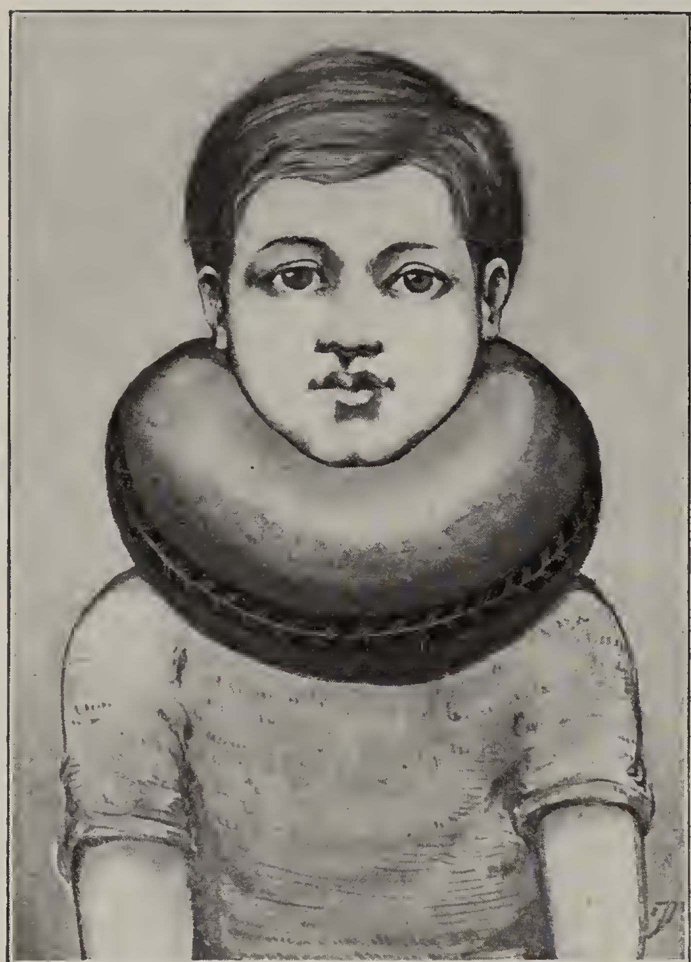


FIG. 379.—PADDED LEATHER COLLAR.

FIG. 380.—BURRELL'S BRASS WIRE COLLAR.

ligamentous structure with fusion of all the parts concerned. The affection is difficult of recognition in the early stages, the symptoms resembling those of

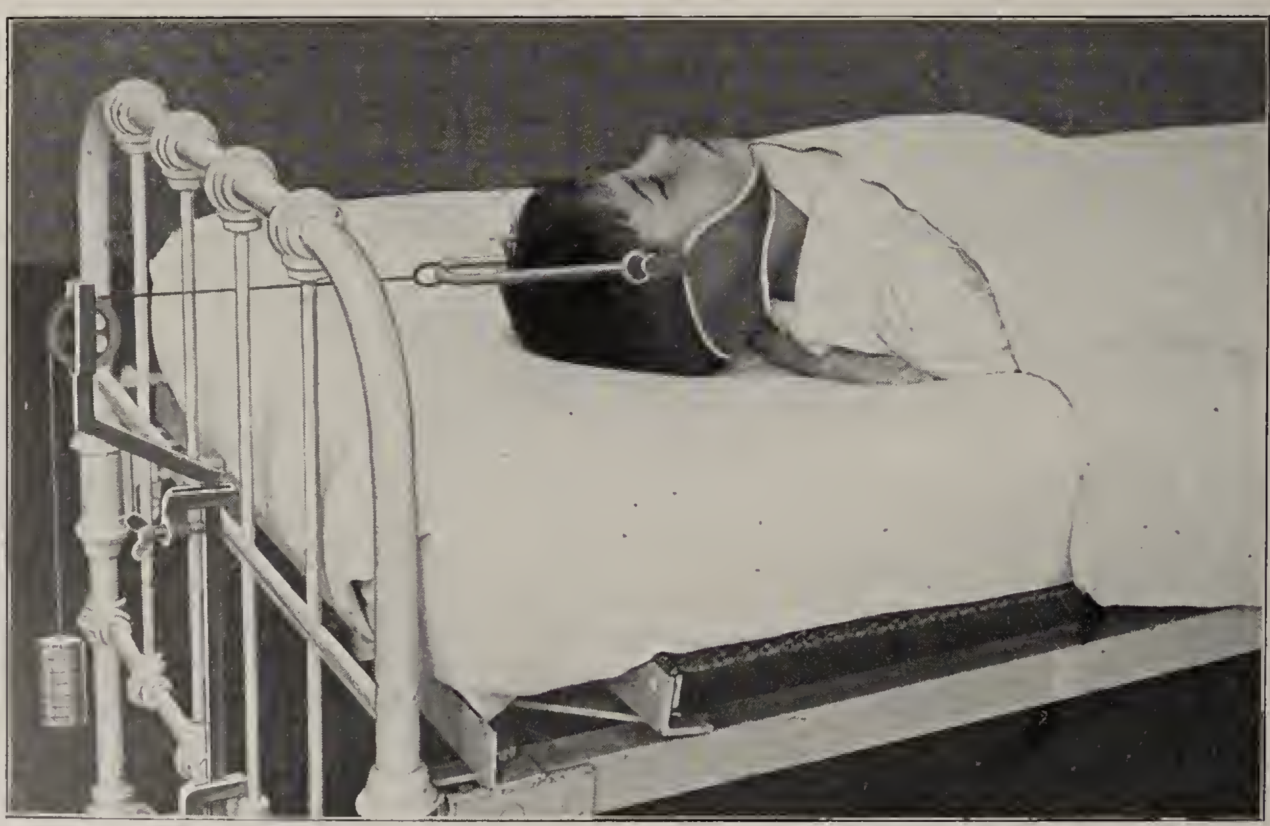


FIG. 381.—VOLKMANN'S METHOD OF EXTENSION IN THE RECUMBENT POSITION.

suboccipital neuralgia. When softening of the ligamentous structures has taken place, the attitude of the patient, as he grasps the head to support it

while in the act of lying down or rising, is characteristic and striking. Sudden death may occur from dislocation (6 out of 10 cases, R u s t). Extensive paralysis may occur. **Progressive myelitis** may occur from gradually increasing pressure on the cord and death take place from this cause.

Treatment is not instituted, as a rule, until after softening of the ligaments has taken place. The indications are to support the head, either by means of V o l k m a n n ' s extension in the recumbent position (Fig. 381) or by means of M a t h i e u ' s cuirass, or one of the head supports already described (Figs. 379 and 380). If abscesses form they are to be opened early.

Bony ankylosis of the upper cervical vertebrae is occasionally found in dissecting-room subjects. The affection is thus far unknown clinically.

TUMORS OF THE CERVICAL VERTEBRAL COLUMN

Certain **congenital clefts** of the cervical vertebral arches occur (spina bifida). Cysts with transparent contents occupy these clefts, which communicate with the enlarged central canal of the spinal cord, and through this with the cerebral ventricles. When a broad communication with the fourth ventricle is present, the case presents a combination of **occipital encephalocele** and **spina bifida.**

The occurrence of a **cervical rib** has been mentioned in connection with aneurism of the subclavian. A genuine **exostosis** of this abnormal cervical rib has been observed (H o l m e s C o o t e).

An accidental **bursa mucosa** may form over one of the spinous processes of the cervical vertebrae, particularly of the seventh. This occurs as a slightly elevated convex swelling filled with a small amount of serosynovial fluid surrounded by somewhat dense walls. It usually arises by pressure from carrying burdens upon the neck. Those greatly thickened must be treated by extirpation. The milder forms may yield to puncture and injection of tincture of iodin, or, this failing, free incision and drainage must be practised.

Sarcomas may develop in the **cervical vertebral** bodies primarily either in adults or in children. This, however, is a rare occurrence. They are most frequently observed as a secondary invasion of the disease and in adults rather than in children. In some instances of supposed primary invasion the original site of the disease has been overlooked. The tendency of the growth is to extend anteriorly toward the pharyngeal wall rather than laterally or posteriorly toward the spinal canal. The disease may likewise spring from the periosteum behind the muscular wall of the pharynx and esophagus. The first symptom usually noticed is some difficulty in swallowing. Palpation of the pharyngeal wall reveals the presence of a small tumor, which may be mistaken for an abscess. **Sarcomas of the vertebral column** grow rapidly and are accompanied by most agonizing pain. When they grow in an anterior direction, they may cause death by starvation or suffocation. If the growth spreads laterally, the sheath of the carotid artery is involved, and death may take place from pressure on the pneumogastric nerve. In view of the utter hopelessness of these cases from the operative standpoint, treatment by the mixed toxic products of the Streptococcus erysipelatis and Bacillus prodigiosus may be tried (C o l e y , see page 226).

Carcinoma.—Dissemination of carcinoma elsewhere, particularly in the breast, leads to deposits in the spinal column. The cervical vertebrae may

become the seat of such deposits. The suffering is most intense, and if the patient lives long enough, suffering may be followed by paraplegia.

TORTICOLLIS (WRYNECK, CAPUT OBSTIPUM)

These names signify an abductory contracture of the cervical vertebral column, in consequence of which the axis of rotation of the head is obliquely placed and the chin is rotated toward the opposite shoulder. The affection may be of **cicatricial, articular, muscular,** or **central (cortical)** origin. The first has already been discussed (page 624). The articular variety was mentioned in connection with inflammation of the joints of the cervical vertebrae, as well as in connection with unilateral spondylitis of the latter.

Wryneck of **muscular origin** is most frequently observed after breech presentations in newborn infants. It results from partial rupture of the fibers of the sternomastoid, and its common cause is traction on the after-coming head. It may be observed immediately after birth, but usually its manifestation is the occurrence of a fusiform swelling, consisting of a mass of so-called **muscular callus,** in the course of the sternomastoid muscle when the child is several weeks old. This may be mistaken for a fibroma or an enchondroma. This **traumatic muscular** hyperplasia usually disappears with treatment, after which shortening of the muscle resulting from cicatricial contraction, and perhaps from a voluntary malposition of the head in efforts to relieve pain, occurs. A peculiar complication observed in cases of long standing is an arrest of development of the corresponding side of the head. This is probably due to pressure on the vessels and nerves of the affected side. This asymmetry usually disappears in the course of time after correction of the deformity.

Wryneck of Central Origin (Spastic Torticollis, Tic Rotatoire).— This affection is a neurosis and has its seat in the brain cortex. It is to be defined as a disturbance in the motor area regulating movements of the head. Symptoms of neurasthenia, and more rarely those of hysteria or mental disease, may coexist. It is most commonly observed in middle-aged persons with either an inherited neurotic taint or an acquired tendency to nervous disease. I have seen two cases occurring in young girls as the result of injury (falling forward and striking on the coronal suture of the opposite side). It is occasionally observed as an occupation spasm. The **symptoms** consist in a morbid contraction of certain muscles of the neck, which is slight at first, of short duration, and easily overcome by the patient. Later it increases in severity and the clonic contraction is converted into a tonic contraction. As a rule, the rotators of the head are affected. The sternomastoid of one side and the muscles of the back of the neck on the other side are usually affected. Exceptionally one sternomastoid and the muscles of both sides of the neck are involved. Still more rarely one sternomastoid and the cervical muscles of the same side are implicated. Occasionally the muscles of the mouth, face, shoulder, and arm take part in the contractions. The **vital prognosis** is good, but the outlook from every other viewpoint is unfavorable.

True **congenital wryneck** of intrauterine origin has been described (G. Fischer). **Spasmodic and paralytic** wryneck have also been described. Torticollis has been observed in children after typhoid fever. The affection has been attributed to shortening of the platysma myoides.

Compensatory scoliosis in the cervical region occurs in connection with scoliosis in the dorsal region.

Treatment.—Wryneck of muscular origin is best treated by section of the sternomastoid muscle. While orthopedic apparatus serve a useful purpose in maintaining a correction obtained by operation, unless the latter has been previously performed they are of little or no avail. In the rare cases which come to the surgeon before shortening from contracture or defective growth of the muscle occurs, a pasteboard collar, plaster-of-Paris bandage, or other means designed to prevent the development of the deformity may be of service. The operation is to be performed under an anesthetic. Either subcutaneous division of the muscle at its sternal and clavicular attachments or open section may be made. The latter is the safer and more efficient method, but is open to the objection, particularly in female patients, that it leaves a prominent scar in an undesirable location. When the former is employed, the tenotome is introduced behind the muscle and the section made from behind forward. When, as is usually the case, the entire width of the muscle is to be divided, it will be, as a rule, necessary to introduce the tenotome a second time, the portion which is most shortened being divided first. An assistant forces the patient's head toward the opposite shoulder, in order to put the muscle on the stretch, and the operator presses his thumb over the point to be divided so as to feel when the fibers give way and thus avoid injury to the skin. Aseptic dressings and plaster-of-Paris bandages are applied after correction of the deformity. The question of the application of one or another of the forms of orthopedic apparatus to maintain correction is to be decided after the healing of the wound. In severe wryneck, as well as in milder cases of long standing, the latter will usually be necessary. In milder cases plaster-of-Paris dressings suffice for the after-treatment.

The treatment of spastic torticollis is almost exclusively operative. Antispasmodics, hydrotherapy, massage, electricity, and cauterization have been used without success. Rigid orthopedic fixation appliances are useless, as far as effecting a cure is concerned. Elastic traction of the head toward the sound shoulder has been successfully used (Hoffa). Stretching or resection of the spinal accessory nerve controls only a part of the affected muscular area and leads to recovery in only one-fifth of the cases and improvement in two-fifths, leaving two-fifths without any benefit whatever. Section of the upper cervical nerves (Gardner, Gilles, Keen) has been introduced as a substitute for division of the spinal accessory. A combination of these procedures (Kocher, Richardson, Walton) gives better results.

In **Kocher's operation** all the muscles that are involved are divided. This will include, as a rule, the sternomastoid of one side and all the cervical muscles of the other side. In the division of the latter the obliquus capitis inferior must not be overlooked. The movements of the head are surprisingly little affected by these extensive myotomies, and whatever impairment does take place is only temporary. Relapses may occur and require repeated division of the muscles until the disease is cured. Gymnastic exercises are to be employed for a considerable time after healing.

The operation is not only palliative, but also curative. The cure is accomplished by the rest given to the irritable center by division of the muscles, the impulses being no longer effectual and resisted. In this way the equilibrium is restored (F. de Quervain).

SECTION XVI

THE SURGERY OF THE THORAX

THE SOFT PARTS SURROUNDING THE CHEST

The skin and muscular structure of the chest wall are seldom injured alone. Among the exceptional injuries in this class are to be mentioned gunshot wounds in which the ball passes for a short distance beneath the skin and then emerges, producing a wound which closely resembles that formerly made for the introduction of a seton, called a **seton gunshot wound.** The so-called **contour shots** are also produced in this way. In the latter class of cases the ball strikes the elastic ribs at a tangent and is deflected outward from the ribs and the intercostal muscles, either issuing again after pursuing a short course or remaining. Occasionally a ball will strike near the sternum and pass around the corresponding half of the chest, emerging near the vertebral column. It is difficult to comprehend the precise mechanism of this injury. Experiments show that a bullet, traversing apparently in a circular direction for about one-fifth of the circumference of the thorax, can have its course changed into a straight line lying outside of the thorax, by sudden rotation of the vertebral column and elevation of the arm (S i m o n , 1871).

Hemorrhage from wounds of the chest wall is not usually troublesome. The subclavian artery is the only vessel of importance likely to be injured. Bleeding from this artery may be arrested provisionally by pressure above the clavicle (see page 626). Permanent hemostasis is secured by ligation at the point of injury, or in continuity (see Ligation of the Subclavian). The long thoracic branch of the axillary artery passes almost vertically downward on the lateral chest wall, somewhat anterior to the axillary line. This, together with the external mammary (superior thoracic) branch, may be injured and require ligation.

Penetrating and Perforating Wounds of the Thorax.—Gunshot wounds constitute the type of this class of injuries. Many of these when inflicted by bullets of the larger calibers prove fatal almost immediately, on account of injury of a large vessel. When both lungs are injured, fatal double pneumothorax develops early. Death may take place from hemorrhage. When but one lung is injured, dyspnea, though urgent at first, is relieved by compensatory expansion of the uninjured lung.

Pneumothorax is sometimes prevented by outward prolapse of the injured portion of lung into the wound of the soft parts by violent coughing efforts; more rarely, in shot wounds by the forcing of the pleural surfaces temporarily on each other in the passage of the ball. The existence of old adhesions may also prevent its development. Pyothorax is difficult of prevention on account of frequent infection from particles of clothing carried along with the bullet in its passage. **Septic pneumonia** and even **gangrene of the lung** may follow.

These complications usually end fatally. Death may also occur from septic bronchitis, edema of the lung, exhaustion from prolonged suppuration and discharge from the bullet track, and paralysis of the diaphragm.

When the lower portion of the chest is traversed by the missile and free drainage is established, spontaneous recovery may take place. When the hemorrhage is due to injury of the smaller vessels of the lung substance, the pneumothorax will usually arrest it. Ice compresses to the chest wall may be employed if the bleeding persists. Resection of portions of one or more ribs for the purpose of tamponing with gauze and thus assuring collapse of lung may be performed to arrest the hemorrhage. Opium should be given, and the most perfect quiet of body and mind enjoined. If hemorrhage from the intercostals is troublesome and tamponing fails to arrest it, splintered fragments of rib may be removed and the vessel included in a suture ligature (circumsuture). Fatal hemorrhage may occur in injuries of the internal mammary artery; the bleeding may take place into the pleural cavity and hence be overlooked. In such a case, if the source of the hemorrhage is discovered, the wound must be enlarged, a portion of costal cartilage resected, and both ends of the vessel secured. This last is rendered necessary by the free anastomosis of this vessel with the deep epigastric.

If **foreign bodies** that have been carried along with the missile can be easily reached, they should be removed. Deep probing for these will be likely to do more harm than good. Loose splinters of bone are to be removed, and the ends of sharp angular fragments resected or rounded off with the rongeur. The parts are to be very carefully and tentatively irrigated with Thiersch's borosalicylic solution. If the irrigating fluid reaches a bronchial tube, as evinced by the paroxysms of coughing and suffocation, it must be abandoned at once.

If the prolapse of lung is slight, the granulations in the wound will cover it in. If considerable, the prolapsed part may be ligated and cut away or removed with the thermocautery. The occurrence of suppurative pleurisy or empyema demands free drainage, with perhaps resection of one or more ribs.

Copious aseptic dressing materials are to be applied and held in place by wide roller bandages. The tight application of broad strips of adhesive plaster encircling the chest will tend to prevent the development of subcutaneous emphysema. Opium is to be given to allay pain and insure quiet. Supporting measures are indicated.

With the introduction of the modern small-caliber mantled projectile of high velocity as a weapon of war the mortality from this class of injuries has greatly diminished. As a result of the smaller size of the bullet and the diminished resistance of the tissues traversed the destructive effects are reduced to the minimum. In the absence of wounds of the heart and great vessels complete and permanent recovery from penetrating and perforating wounds of the chest is not unusual, as shown by the most recent experiences in active military service (Makins).

Inflammation of the Soft Parts of the Chest Walls.—Suppurative inflammation following gunshot wounds of the chest easily takes on a phlegmonous character, from infection of the large and loose planes of connective tissue which surround the muscular layers of the thoracic wall. Gunshot

wounds of the upper dorsal region at the inner margin of the trapezius and latissimus dorsi are usually followed by a suppurative process with a constant tendency to extend in a downward direction, and consequent pocketing of pus until the sacral region is reached. Repeated incision, drainage, and antiseptic irrigation are indicated.

Subpectoral Phlegmonous Inflammation; Subpectoral Abscess.—This is a diffuse suppurative inflammation of the connective tissue behind the pectoralis major muscle. It is usually the result of a streptococcus infection, transmitted through the supraclavicular and infraclavicular lymphatic channels. The infection is derived from wounds in the neck or on the corresponding side of the chest; a slight abrasion of the skin may be the atrium of infection. There may be a history of a strain or blow. A suppurative collection sometimes takes place behind the pectoral muscle from abscesses within the chest which perforate the chest wall, or it may result from necrosis of the ribs, of tuberculous origin.

Besides the usual general symptoms of phlegmonous inflammation, the patient complains of pain over the corresponding pectoral region, particularly when the arm is moved so as to bring the pectoralis major muscle into play. The swelling may be so diffused beneath the muscle as to render its recognition difficult. Tenderness, however, may be pronounced. The skin overlying the pectoralis major muscle remains unchanged, except in the rare instances in which the muscle is involved by an exceptionally virulent infection, in which case edema, and, finally, an inflammatory redness will be observed. In rare instances the phlegmonous character of the inflammation may give place to a localized process, a true abscess resulting. The suppurative process tends to pass in the direction of the outer edge of the pectoralis major and the lymphatic glands at this point become infected; infection of the axillary glands may also occur. The presence of pus will be announced by a soft swelling, with tenderness, and later on by involvement of the skin. Spontaneous evacuation may occur at this point. In neglected cases general sepsis, and even metastatic pyemia, may occur.

Treatment.—Early operative interference is imperative. An incision should be made to the outer border of the pectoralis major muscle, and the site of the suppurative process sought by passing the end of an artery forceps or other blunt instrument behind the great pectoral muscle. Thorough curetting of the debris of broken-down tissue found to be present, cleansing with an antiseptic solution, and tube drainage are indicated. Infected subpectoral and axillary glands should be dissected out. In cases of spontaneous evacuation a discharging sinus is liable to remain. These sinuses are sometimes persistent in spite of frequent curettings; excision of the entire suppurating tract may be required before healing can be secured.

When the muscle itself becomes involved and a circumscribed abscess tends to point anteriorly, the latter may be evacuated by a direct incision.

More or less impairment of the movements of the shoulder-joint may result from interference with the free play of the pectoralis major muscle. The proper treatment for this condition is massage and passive and active movements of the joint.

Nonsuppurative Mastitis; Mastitis of the Newborn.—A peculiar form of distention of the breast occurs in newborn infants of both sexes, from

which a milklike fluid sometimes exudes. It is doubtful, however, if this is a true mastitis.

Mastitis in the Male.—A nonsuppurative mastitis is sometimes observed in male youths between the ages of twelve and sixteen years.

Mastitis adolescentium seems to bear some relation to sexual development. Slight contusion may be an exciting cause. The affection appears as a painful, and perhaps tender, swelling of the gland; a colostrumlike fluid may sometimes be pressed out of the latter. The condition is analogous to **menstrual irritation of the mammary gland in young females.**

Gynecomastia is an abnormal development of the mammary glands in the male. It is sometimes accompanied by atrophy of the testicles.

Chronic mastitis or **interstitial paradenitis** is a diffuse proliferation and condensation of the connective tissue between the lactiferous ducts and the acini. The condition attacks women of forty and upward and seems to bear some relation to the menopause. It is usually bilateral. Care should be taken not to confound the disease with fibrous carcinoma or scirrhus, in the cases in which the disease is unilateral, and in which marked cicatricial contraction (cirrhosis of the mamma) has occurred.

Treatment.—Extirpation of the breast is the only safe remedy. In view of the tendency toward malignant disease any persistent induration which within a few weeks does not show signs of retrogression under massage and inunctions of a 10 per cent ichthyol lanolin mixture should become the subject of at least exploratory incision and microscopic examination. To wait until the glands are involved is, in many instances, to doom the patient. Painting the breast with tincture of iodin and injections of iodin solutions have been recommended.

Tuberculosis of the mamma is very rare. But a single case in which the diagnosis was established has been reported (Poirier). Syphiloma of the breast is of doubtful occurrence.

Suppurative Mastitis. — Suppurative inflammation of the mammary gland is almost exclusively confined to nursing women. It occurs, though rarely, in newborn children of both sexes, when it is not infrequently the result of violent efforts on the part of the nurse or the midwife to force milk from the breast of the infant. It may occur as a metastatic inflammation during the first few days following delivery, and under these circumstances it bears the same relation to injuries of the parts involved in the delivery as do puerperal metritis and parametritis resulting from septic infection. This is favored by increased functional activity.

The inflammation develops most frequently during the third and fourth weeks following delivery, and under these circumstances it is usually due to infection from fissured or abraded nipples, or abrasions or eczematous conditions about the base of the nipple or areola. The infection occurs in the connective tissue surrounding the excretory ducts and the lobules of the gland. The lymphatic spaces surrounding the ducts are particularly liable to infection. The inflammation may radiate from the nipple to the outlying glandular structure and an abscess form on the periphery of the gland. As soon as the suppurative inflammation extends beyond the limits of the gland and invades the loose connective tissue separating the latter from the pectoralis major muscle,

it assumes a phlegmonous character and **retromammary phlegmon** is added (**paramastitis,** Billroth).

The **symptoms** of suppurative mastitis will vary with the extent and virulence of the infection. A small focus of infection situated in the gland itself may give rise to but a slight elevation of temperature, while a retromammary phlegmon may give rise to the most serious disturbances. In the latter variety the absorption of the septic products of inflammation is favored by the pressure of the overlying swollen gland. In extensive suppurative inflammation confined to the breast itself, the marked development of lymphatic vessels during lactation favors absorption of inflammatory products. The axillary, and more rarely the subclavian glands are affected, though these rarely suppurate.

Prognosis.—The usual tendency of suppurative mastitis is toward recovery, though suppurative fistulous tracts may persist for a long time. These may communicate with the lactiferous ducts and both milk and pus discharge from the orifices (**lacteal fistula**). The principal obstacle to healing is defective drainage, particularly in cases of retromammary phlegmon. Under these circumstances new abscesses form constantly, until the entire gland and retromammary tissues are infiltrated and riddled with discharging fistulas.

Treatment.—The preventive treatment consists in cleansing the nipple with an antiseptic solution after each time of nursing. Already existing fissures and abrasions are to be touched with either sulfate of zinc or nitrate of silver. At the commencement of the inflammation the breast should be covered with compresses wrung out of a 2.5 per cent solution of carbolic acid, covered with oiled silk and cotton batting, and the breast bandaged in suspension (Fig. 209). Nursing should cease at once and the breast should be kept free from secretion by use of the breast-pump.

As soon as suppuration occurs, free incision is indicated. Occasionally pointing occurs late and appears in the shape of a slightly softened and particularly tender spot in the swollen gland. Here a skin incision, followed by blunt boring with a director or dressing forceps, will finally reach the suppurating focus. Incisions should always be made in a direction radiating from the nipple, in order to avoid cutting across the lactiferous ducts.

In case retromammary phlegmon has occurred the patient must be anesthetized and the suppurating focus behind the gland sought for and incised from the periphery of the gland, but not through its substance. Any openings already made in the breast may be utilized in the search, but the incision which gives free access to the retromammary tissues must be made through the soft parts of the chest wall in a position to give the readiest access, the influence of position in its relation to free drainage being also borne in mind.

Extensive **streptococcal infection** with multiple small foci of suppuration scattered throughout the breast, these finally coalescing to form abscess cavities of various sizes, is sometimes observed. There is marked constitutional disturbance present, and often great prostration. Ablation of the entire organ is usually necessary, in these cases, in order to arrest the systemic infection. Sometimes more or less comparatively healthy skin can be saved to hasten the healing process.

In cases of **multiple mammary fistulas** in which, through neglect early in the case, multiple foci of suppuration have formed and the function of the gland is practically destroyed by cicatricial contraction and obliteration of the lactif-

erous ducts and acini, and in which the fear of supervention of fibrous carcinoma (scirrhus) may be reasonably entertained, **extirpation** of the mamma is to be resorted to.

The treatment of lacteal fistulas consists in frequent cauterizations with nitrate of silver. They may persist because of the presence of pus and infected granulations. Thorough curetting is to be employed in these cases.

Neuralgia of the breast (mastodynia) probably depends upon nerve pressure in the course of chronic interstitial mastitis. It is sometimes difficult to differentiate between neuralgia of the breast and intercostal neuralgia. In severe cases, when the usual general measures of treatment of neuralgia have failed, amputation may be resorted to.

NONMALIGNANT TUMORS OF THE MAMMARY GLAND

Congenital supernumerary mammary glands (polymazia) are analogous to the lacteal glands of mammals. In some cases two or more distinct nipples and areolae appear on a single gland. Supernumerary glands have been observed in the axilla and on the outside of the thigh (Robert). This abnormality has been observed in the male sex (Sanderson).

Giantlike growth of the mammary gland occurs at the period of adolescence. Both mammae are usually involved. The size and weight of the breasts may be enormous. Internal and external use of iodin are recommended. Extirpation may be resorted to in extreme cases.

Adenomas.—These constitute a common form of tumor of the breast. They occur principally in young women of from sixteen to twenty years of age. They are situated away from the nipple and most frequently near the lower edge of the pectoralis major muscle. These tumors rarely exceed an egg in size, averaging the size of a hazelnut. They are of a consistency harder than that of the breast; transitory forms doubtless exist between adenoma and fibroma (Billroth). Adenomas increase in size temporarily at menstruation. They are of slow growth and are situated at varying depths from the surface. The **treatment** consists of extirpation. The benign character of the growth, when assured by microscopic examination, gives immunity from recurrence. On the other hand, the possibilities of carcinomatous and sarcomatous development from adenoma and adenofibroma of the breast are such as to justify the removal of the tumor in every instance.

Fibromas and **lipomas** of the mamma are rare. The variety of the latter which makes its appearance behind the breast (retromammary lipomas) should be mentioned. Fibroma may develop from adenoma or independently; lipomas, as well as pure fibromas, are seen most frequently in the male breast. **Enchondromas** with partial ossification have been reported (Cooper). **Atheromas** are occasionally seen at the areola and nipple.

Cysts of the Mamma.—Cystic dilatation of the lacteal ducts, with milky contents, is called galactocele. True cysts, multiple or single, with firm walls (**fibrocystoma**), or in conjunction with malignant disease (**cystocarcinoma**) are observed. Simple cysts with clear contents are not uncommon. Sometimes the contents are of the consistency of butter (butter cysts). Deposit of calcareous and other salts in the cysts following thickening of the contents of the latter constitutes the so-called **mammary** or **lacteal calculi.** The treatment of benign cysts is puncture and subsequent injection of tincture of iodin.

If they persist, they should be removed. **Echinococcus** cysts have been observed.

Malignant Papillary Dermatitis (Paget's Disease of the Nipple).—This consists of an abnormal development of the interpapillary processes, with frequent obliteration of the papillae. It affects almost exclusively the nipple and surrounding areola of women in the cancerous age, and is usually followed, in the course of two or three years, by carcinoma of the breast. Its existence may extend over a period of from ten to twenty years.

Etiology.—The disease is probably cancerous from the outset, though its malignancy is claimed by some to be a secondary phenomenon resulting from constant irritation and infection.

Symptoms.—The appearances are those of a moist eczema. The nipple and areola present a raw, granular surface, from which a clear viscid fluid exudes. The edges of the affected area are well defined; in old cases there is considerable infiltration. Tingling and burning are present. The disease may be mistaken for ordinary eczema of the nipple. The latter, however, is usually bilateral and lacks the sharply defined border of Paget's disease as well as its excessive rawness. Finally, carcinomatous nodules, appearing first in the lactiferous ducts, and retraction of the nipple, occur in Paget's disease.

Treatment.—As soon as the diagnosis is assured, the entire breast is to be removed. While the disease may last for a long time without manifest deterioration of the health, it will sooner or later prove fatal unless operative treatment is resorted to.

MALIGNANT TUMORS OF THE BREAST

These are far more frequent than benign (82 out of 100, Billroth).

Sarcomas.—These are of rare occurrence compared with carcinomas of the breast. The presence of cystic spaces in these growths has given rise to the term "adenosarcoma." Both the round-celled and the spindle-celled variety may occur. Hyaline cartilage and even bone may be present. The round-celled variety grows rapidly, particularly in nursing women. The spindle-celled variety grows more slowly. The disease develops between the twentieth and the thirtieth year. A moderately hard and painless tumor is present. Secondary lymphatic glandular involvement occurs late, if at all. When the growth breaks down it may simulate a **myxoma.** The actual occurrence of the latter as a primary form of the disease is probably extremely rare, though a myxosarcoma characterized by the presence of striated muscle elements is described (Billroth).

Melanosarcoma is the rarest of all mammary tumors. So-called "**cystic sarcoma**" is that form in which various sized cystic spaces develop, these originating probably from the lactiferous ducts and acini in the immediate neighborhood of the growth. Sometimes a peculiar leaf-like proliferation is present in one of the cysts (**phylloid cystic sarcoma**).

Carcinoma of the Mamma.—The favorite starting-point of cancer of the breast is in the acini; exceptionally it occurs in the ducts.

Acinous carcinoma is the most frequent as well as the most dangerous variety of mammary cancer. It may attack any portion of the glandular structure, but it affects the base of the nipple by preference, where it induces

early retraction. In other portions of the gland, as involvement of the skin takes place, retraction of the latter follows.

The growth is devoid of a capsule on section and indefinitely infiltrates the entire gland. A roughened, leathery sensation is imparted as the growth is incised after removal, and the cut surfaces present the appearance of an unripe pear. Sections under the microscope present the usual appearances of alveolar spaces filled with epithelium, representing the columns of cells characteristic of carcinoma. The columns are arranged in the lobules of the gland and are embedded in dense fibrous tissue. Isolated collections of cells may be identified well beyond the apparent limits of the tumor. The proportion of fibrous tissue will vary greatly, and on the amount of this tissue present will depend the solidity of the growth. In the variety commonly called "**scirrhus**" the fibrous tissue is proportionately abundant (**fibrous carcinoma**); the growth proceeds slowly and contraction of the gland takes place, the breast being markedly lessened in size. Carcinoma sometimes arises in a supernumerary mammary gland in the axilla.

Fig. 382.—Scirrhus Carcinoma in the Male Breast. Four years' duration. Inoperable. Death in five months with lung involvement. (Patient of Dr. Walter C. Wood.)

The age for the appearance of acinous carcinoma of the breast is between the fortieth and the fiftieth year, but cases of patients between thirty and forty are not uncommon. It is rare before thirty and after seventy. About one per cent of the cases occur in the male. Blows, overlactation, and preexisting mastitis, particularly where suppuration has occurred, may be considered as taking part in the etiology. Rarely both breasts are concurrently attacked.

The tumor appears insidiously and is of slow growth, except during lactation, when it grows very rapidly. It is painless at first and rarely assumes large dimensions; one larger than the fist is uncommon. Infiltration occurs early, particularly in cases in which the fibrous tissue is less abundant. The pectoral fascia and pectoral muscle become invaded, the channels of infection being the lymphatic vessels which pass transversely through the latter (Heidenhain).

Lymphatic glandular infection occurs early; this and the lessening in size of the breast, when taken in conjunction with the presence of a tumor, constitute the most valuable diagnostic signs of carcinoma of the breast. The glands at the free border of the pectoralis major are first affected, those in the axilla follow, and finally those above the clavicle become involved.

The skin becomes invaded, causing dimpling or puckering; in some cases it becomes involved in the shape of small nodules which appear like duck-shot or split peas in the substance of the skin (lenticular skin involvement, see Fig.

383). Ulceration is preceded by a brownish or a bluish appearance of the skin. The destructive process may proceed rapidly and deeply in some cases (Fig. 383). In others the growth proceeds more slowly and the tumor projects above the surface in the shape of a fungating mass. Pain is not usually a prominent feature until the later stages of the disease are reached, and some patients are free from it altogether.

Dissemination takes place, as a rule, following the lymphatic glandular

Fig. 383.—Advanced Carcinoma of the Breast.

Showing the ulcerated and excavated mammary gland, carcinomatous infiltration of the chest wall and of the deep cervical glands of both sides, lenticular recurrences in the skin, and extreme edema of the lower part of the arm, forearm, and hand from pressure of enlarged glands on the vessels in the axilla.

infection. The secondary deposits take place in the viscera, especially in the lungs and liver, but they may take place in any organ. Hydroperitoneum follows secondary deposits in the liver, pneumonia and pleurisy those in the lungs and pleura, mental disturbances and coma those in the brain, and paraplegia, preceded by intense suffering, those in the vertebral column. Deposits in the bones are sometimes followed by spontaneous fracture, even in patients who are bed-ridden (fracture by muscular action). Extensive dissemination in the chest wall produces extreme induration in the skin, due to the invasion

of the lymphatics of this structure; the latter becomes coarse in appearance and hard and unyielding (cancer en cuirasse).

Progressive emaciation may be a marked and early feature; yet in a certain proportion of the cases this is not present until the disease is well advanced. It is quite common for the patients to be up and about until very late in the disease.

Lymphatic edema is an occasional complication of cancer of the breast. It is due to the pressure of infected and infiltrated lymphatic glands and secondary nodules on the main lymphatic channels in the apex of the axilla, or close to the chest wall in Mohrenheim's fossa. It usually involves the entire upper extremity, commencing, as a rule, in the neighborhood of the shoulder and even involving the scapular region. The connective tissue is infiltrated with lymph and the skin is firm, brawny, and unyielding. The movements of the joints are interfered with and the limb becomes a burden to the patient (Fig. 383). This condition is usually present as a late complication in the natural history of the disease, or it may occur in late operative cases irrespective of whether the axillary glands have been removed or not. It may simulate the dissemination in the skin known as "cancer en cuirasse." The dropsical condition of the arm which sometimes follows the complete operation for cancer of the breast and which is due to cicatricial interference with return circulation should not be mistaken for lymphatic edema. In the former the skin will pit on pressure, while in the latter the skin, instead of pitting, will be firm and unyielding. In some instances, however, the condition present is due to a combination of the two causes. When pain is present, it is due to pressure on the nerve-trunks by the enlarged glands, or to secondary growths.

Carcinoma of the ducts occurs just before, at, or after the menopause. The growths arise in the dilated ducts or "involution cysts" so frequently present in connection with atrophy of the glandular structure due to the climacteric period. The dilated ducts or cysts are occasionally the seats of new growths such as papillomas and carcinomas. Dilated terminal ducts, and particularly the ampullae or lacteal sinuses, are the favorite localities from which these growths spring. The tumor usually occurs singly, is of slow growth, varies in size from an English walnut to a goose-egg, and when situated near the skin presents some discoloration suggestive of melanosarcoma. The growth lacks the hard fibrous feel of the acinous variety. An abundant discharge of dark thin fluid from the nipple is usually present. The lymphatic glands are rarely infected, dissemination scarcely ever occurs, and recurrence following the removal of the entire breast is uncommon.

The **prognosis of carcinoma of the breast** is always unfavorable if the disease is allowed to pursue its natural course. The average duration of life without operation is twenty-two months (combined statistics of Winiwarter, Fischer, and Esmarch). Death takes place from ulceration, sepsis, hemorrhage, and exhaustion. In addition to the breast and subpectoral and axillary lymphatic glands, the retromammary fascia and fat, which connect by numerous lymphatic channels with the breast, the sheath and substance of the pectoralis major muscle, the intercostal muscles, periosteum, ribs, pleura, and lung become affected. Numerous nodules also appear in the skin of the thoracic wall, both laterally and posteriorly. Finally, secondary deposits occur in the brain, vertebral column, the bones, etc.

Scirrhus of the breast in males has been noted in 7 out of 252 cases of the disease (Billroth). The other varieties of malignant disease are also rare here.

The **treatment** of malignant tumors of the mamma consists in total removal of the diseased breast and of all neighboring lymphatic and other suspiciously affected structures. The condition of pregnancy is not to be considered a contraindication to operation. The existence of lymphatic involvement may not be demonstrable until after the parts are exposed by turning back a flap of skin. It is not enough simply to enucleate the individual glands; the entire fatty and connective tissue, the lymphatic glandular contents of the axillary cavity, the loose connective tissue between the latissimus dorsi and the

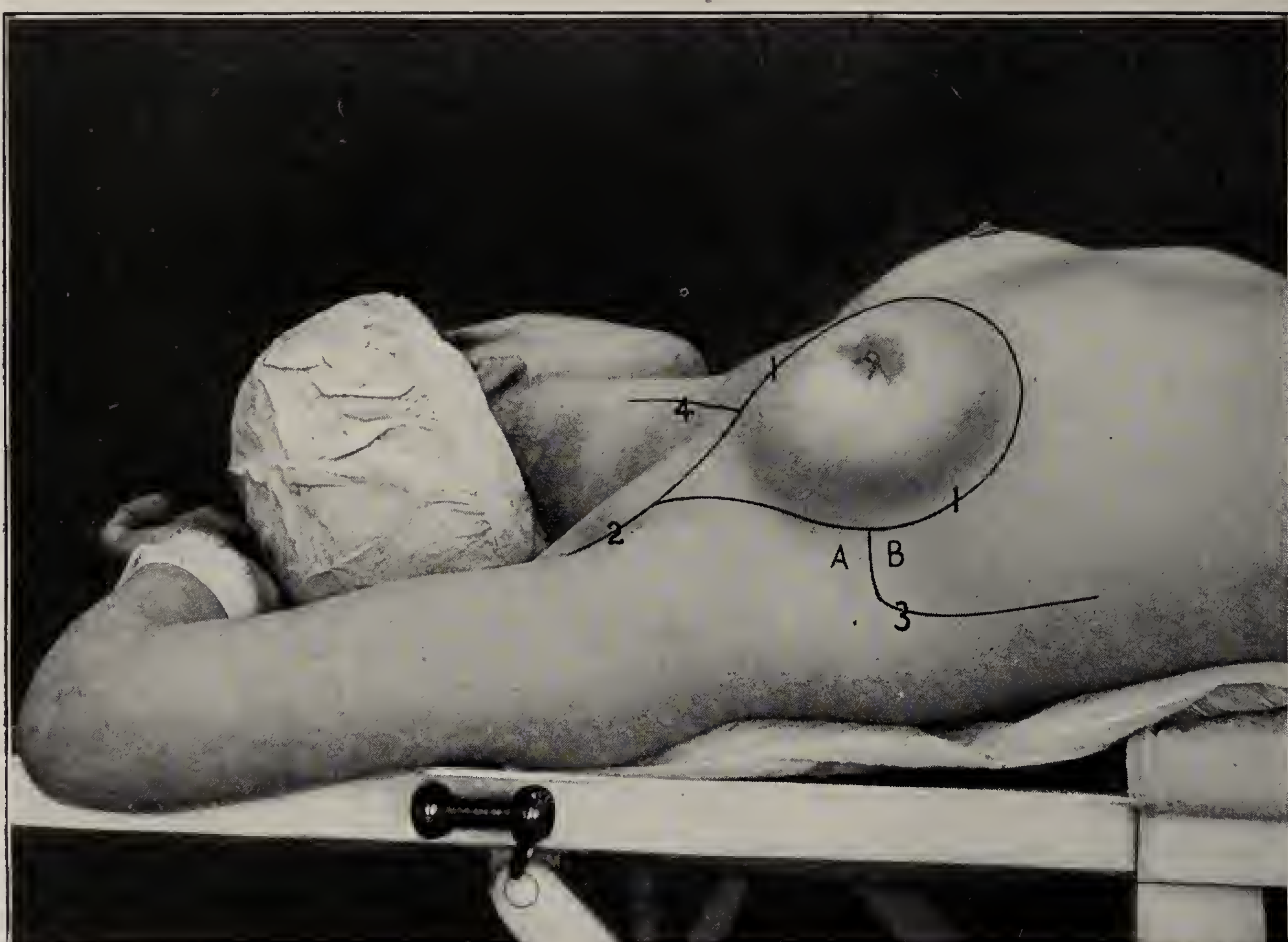


Fig. 384.—The Radical Operation for Carcinoma of the Breast.

The lines of incision for amputation of the breast for carcinoma. 1, 1, Elliptic incision surrounding the breast; 2, axillary incision; 3, incision made in formation of flap for closing the gap left after removal of the breast (Warren); 4, incision for removal of supraclavicular glands. (The final disposition of flaps A and B is shown in Fig. 389.)

pectoralis major muscle, the glands and connective tissue lying beneath the latter muscle and passing from it to the mamma, and, finally, except in the very beginning of the disease, the pectoralis major muscle, and if necessary the pectoralis minor as well, must be completely extirpated. These structures should all be removed in one piece, in order to prevent the wound from becoming infected by the division of tissue invaded by the disease or by lymphatic vessels containing cancer cells, as well as to effect complete removal of all cancerous tissue (Halsted).

The Radical Operation for Malignant Disease of the Breast (Willy Meyer; Halsted; Warren).—This operation aims at complete removal of the gland, the immediately underlying muscular parts, and the

glandular and fatty contents of the axilla. The incisions will necessarily vary with the location of the tumor. In the majority of cases the following method, developed by Willy Meyer, may be followed: The patient's arm is held by an assistant either at right angles with the body, or alongside the head. The first incision commences at the humeral attachment of the pectoralis major, and is carried by a gentle sweep around the outer border of the breast and finally around the lower border. The second incision commences at the middle of the anterior axillary fold and is carried around the upper and inner margin of the organ, meeting the first incision at its terminal point. A flap is now marked out on the outer side of the pectoral region by dividing the skin above the middle of the first incision and carrying the cut at right angles to the latter; then curving it until it becomes parallel to the level of the lower

Fig. 385.—The Radical Operation for Carcinoma of the Breast. Dissection of the integument with "undercutting" in an oblique direction.

margin of the wound and finally terminates at a point a little below it (J. Collins Warren, Fig. 384). This flap is to be afterward utilized in closing the gap. In case of lymphatic involvement in the cervical region an additional incision is made, which is commenced at the middle of the second incision and carried across the clavicle and along the posterior border of the sternomastoid.

The surrounding skin is to be dissected freely in all directions, including the axilla, so as to remove as much of the surrounding fat as possible with the breast. Where the incisions lie adjacent to the latter, the method of "undercutting" in an oblique direction facilitates this step of the operation. The dissection should expose the cephalic vein and the clavicle; the fat overlying the pectoralis major muscle, as well as that covering in the

axilla back to the latissimus dorsi and running down on the lateral chest wall, should be allowed to remain and come away with the breast, glandular structures, and fat in the final removal.

The lower border of the pectoralis major is now identified, and the course of the cephalic vein as it lies between the pectoral muscle and the deltoid determined. The forefinger of the left hand of the operator is now introduced from below so as to isolate the humeral insertion of the pectoralis major, and the latter divided close to the bone by stout blunt scissors. If a portion of the attachment is allowed to remain, it is likely to slough. The muscle is now further loosened until its clavicular attachments are reached. An assistant now holds the muscle and breast toward the median line while the operator identifies the pectoralis minor muscle and raises it on his fingers and divides it (Fig.

Fig. 386.—The Radical Operation for Carcinoma of the Breast.
Exposure and division of the humeral attachment of the pectoralis major muscle.

386). The triangular shaped space lying behind the latter muscle and bounded internally and posteriorly by the chest wall (M o h r e n h e i m) is thus exposed. In this space are to be found the vessels and nerves of this region and the glandular structures most frequently infected. The thin layer of fascia overlying the vessels is now divided. The vein is to be first identified and the utmost pains taken not to injure this, as the glandular structures, as well as the fatty and loose connective tissues, are carefully and systematically dissected (not torn) away. The artery will always announce its presence by its pulsation, and the nerve cords of the brachial plexus, from their larger size and hard feel, are more or less constantly in evidence. But the vein is easily obliterated by slight pressure in the course of the manipulation and hence may be inadvertently injured.

The entire glandular and fatty contents of the axilla and Mohrenheim's fossa are dissected loose except where they join the breast and pectoralis major muscle. In this dissection the latissimus dorsi muscle is exposed before the fat layer is finally cut through. The remaining attachments of the pectoralis major (clavicular, sternal, and costal) are now divided in succession, the entire mass turned in an outward and downward direction, and the removal effected by completing the section on the outer margin of the breast through the remaining attached fat layer. The vertical incision may be utilized in the search for infected glands in the clavicular region and extend up on the neck in clearing out any suspicious growths in the supraclavicular region.

In patients whose condition will not permit a greatly prolonged operation

Fig. 387.—The Radical Operation for Carcinoma of the Breast.
The muscles divided and the mass retracted, exposing the axilla and giving ready access to Mohrenheim's fossa.

it is better to accept the remote risks of a subsequent recurrence from cancerous infection occurring during the operation than to court the immediate dangers of fatal operative shock. Under these circumstances the operation may be considerably shortened by first removing the breast and then the pectoralis major muscle. The pectoralis minor is then divided (*vide supra*) so as to give ready access to Mohrenheim's fossa and enable the operator safely to clear this and the axillary region of suspicious appearing tissues in a comparatively short space of time.* The divided pectoralis minor muscle may be sutured with

* Theoretically the dissection of the breast from the muscle is objectionable from the fact that the presumably infected lymph-channels lying behind the breast are opened up This is no more true, however, than in the case of the removal of the axillary glands and those lying on the edge of the great pectoral muscles, when these are indubitably infected.

catgut. It always unites and resumes its function. The latter, however, is not of great importance, and the muscle may be removed as a routine procedure along with the pectoralis major.

Where a still more conservative course is indicated, and in exceptionally early cases, simple removal of the breast and extirpation of the axillary glands may suffice. In this class of cases the elliptic incision with extension of the same to the axilla may be employed (Fig. 390).

In closing the wound the axillary flap is first forced well up in position by a pad of sterilized gauze in the axilla, so as to elevate the fornix of the latter as much as possible and obliterate the "dead space" which otherwise would exist, the arm being brought down to the side at the same time. In aseptic cases no

Fig. 388.—The Radical Operation for Carcinoma of the Breast. Exposure and division of the pectoralis minor muscle.

drainage is required. The thoracic wound is closed as completely as possible. If a gap remains, this may be filled with Thiersch transplantation strips immediately, or when granulation is well under way. Where Warren's flap is employed excellent approximation can usually be obtained. It should be placed in position and sutured with as little tension as possible, in order to avoid endangering its vitality (Fig. 389). Failure to observe this precaution not infrequently leads to gangrene.

In **Halsted's original method** the steps of the operation are mainly in the reverse order from those just detailed. These include the following: (1) The reflection of a triangular shaped skin flap (Fig. 391). The fat layer at the site of this flap is dissected back to the lower margin of the pectoralis major muscle. (2) The pectoralis major muscle is severed first at its costal and then at its clavic-

ular insertions, and finally at its humeral attachment. (3) The whole mass thus far loosened is stripped from the thorax and from the pectoralis minor muscle.

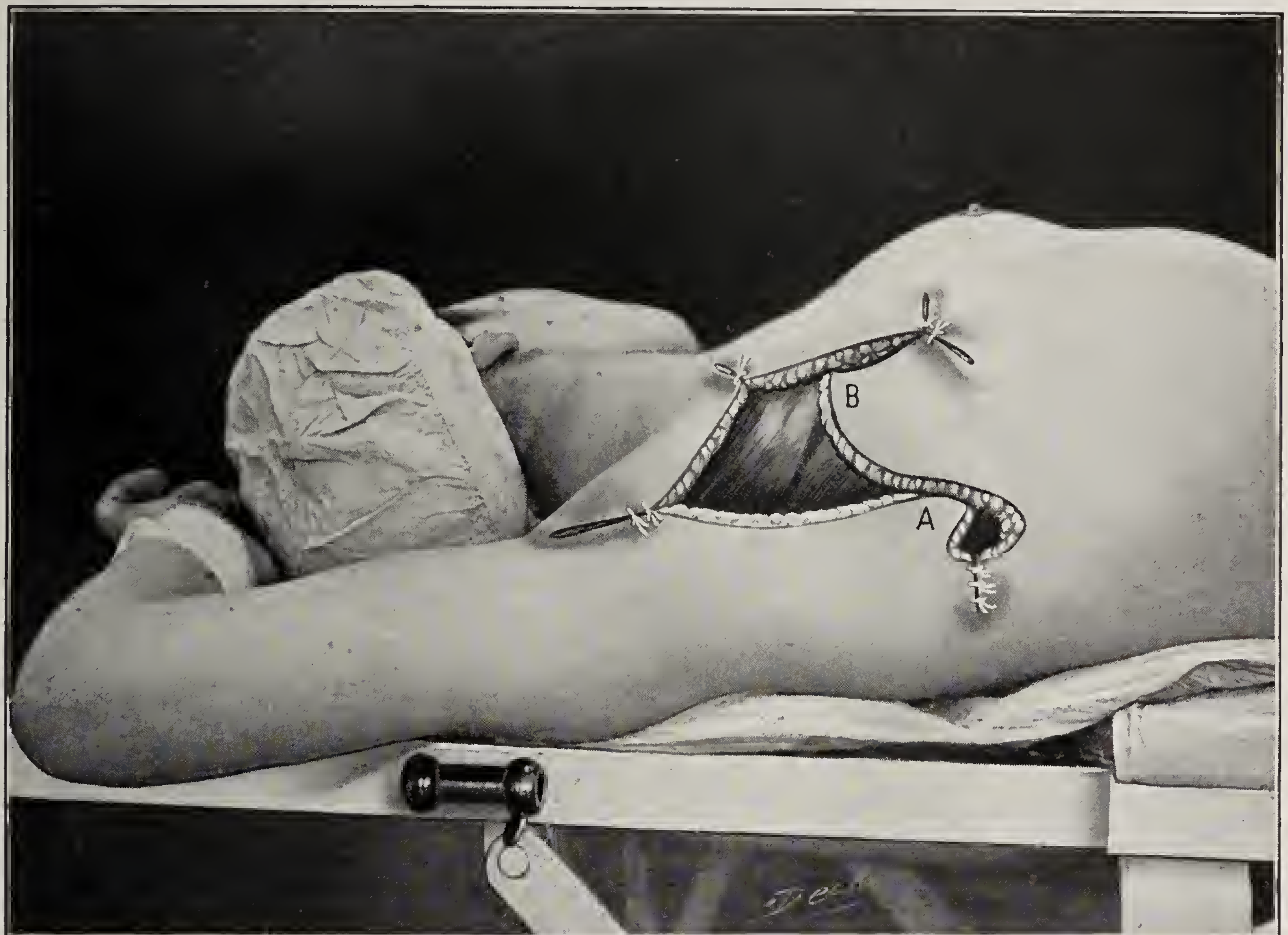


Fig. 389.—The Radical Operation for Carcinoma of the Breast. Mode of closing the wound when Warren's flap is employed.

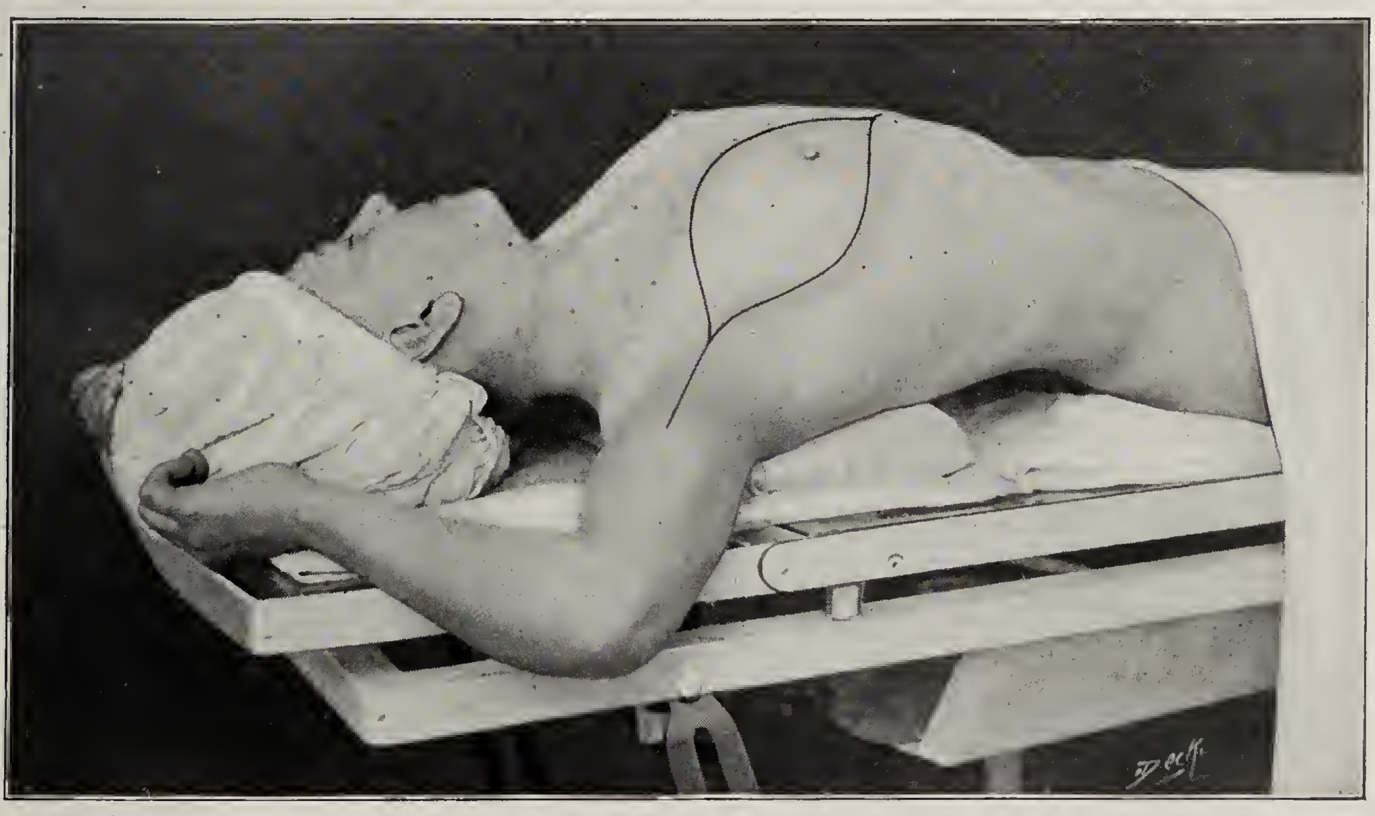


Fig. 390.—Elliptic Incision for Simple Removal of the Breast and Extirpation of the Axillary Glands.

(4) The pectoralis minor muscle is cleared and divided across near its middle, and the tissues near its coracoid insertion, together with the loose connective tissue lying under the muscle itself, are dissected away. (5) The subclavian

vein is exposed at its highest point, and the contents of the axilla, including the loose tissue above the vessels and about the brachial plexus of nerves, carefully dissected (not pulled) away. After the vessels and nerves are cleared the lateral wall of the thorax is stripped, and finally the posterior wall of the axilla. The

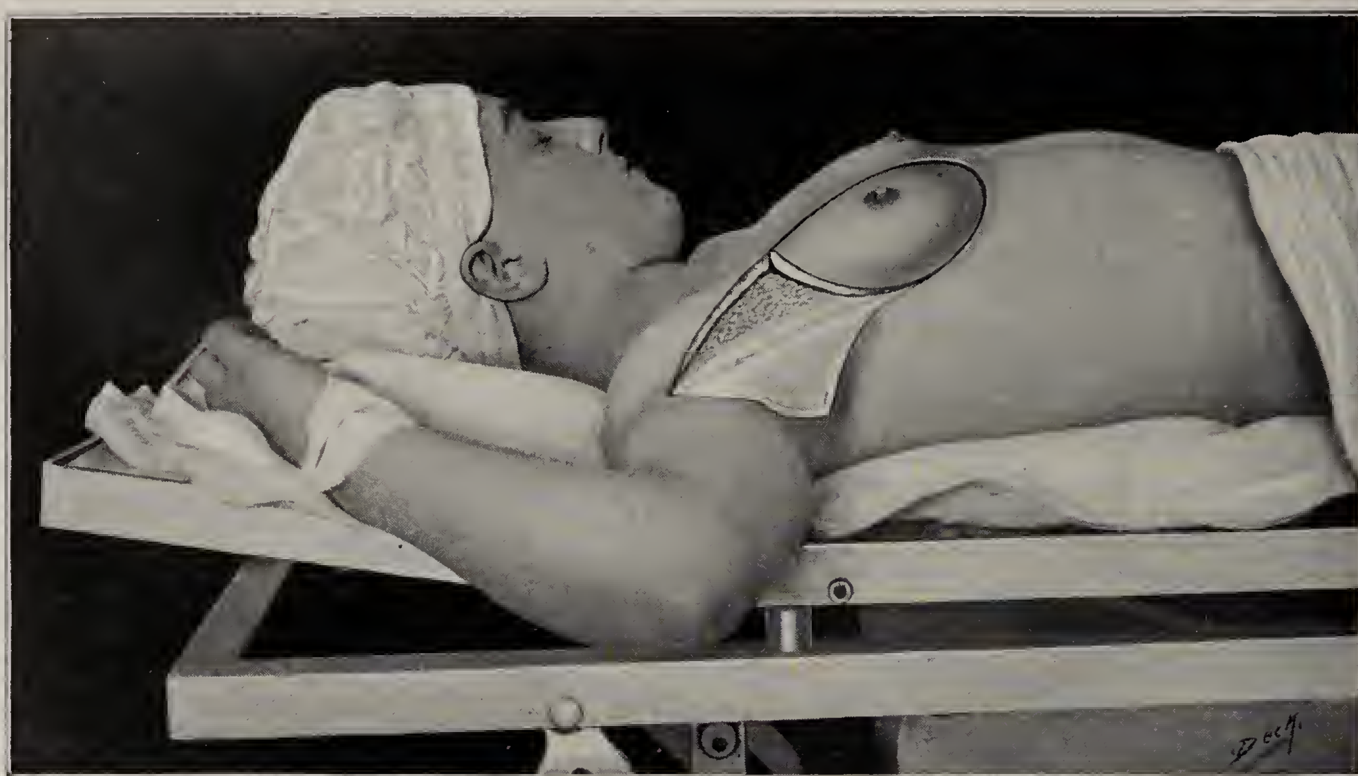


Fig. 391.—Halsted's Radical Operation for Carcinoma of the Breast. Showing the lines of incision and the reflection of the flap.

Fig. 392.—Halsted's Radical Operation for Carcinoma of the Breast. The mass turned back.

mass is now held only at the posterior line of incision (Fig. 392). This is severed by a few strokes of the knife.

In closing the wound it is important to apply the triangular shaped flap closely to the fornix of the axilla by a mass of gauze crowded well up in the axillary space. This obliterates the dead space and lessens the amount of

cicatricial tissue formed, thereby reducing to a minimum the subsequent disability of the arm.

When the subclavian artery and vein pass through the glandular growths and are intimately attached thereto, they have been extirpated with the latter between two ligatures. This condition is rarely encountered, however, for the reason that it is present only in those advanced cases in which operation should not be undertaken. In cases otherwise favorable for operation the lymphatic and fatty structures in the axilla can usually be dissected from the blood-vessels and nerves. Glandular involvement in the supraclavicular region renders the prognosis unfavorable.

Whatever method of operation is adopted the skin incisions must be made wide of the diseased area and so placed as to afford ready access to the entire mammary region, and by extension to the axillary, infraclavicular, and subpectoral regions as well. In making the deeper dissections the blood-supply should be taken into account and the vessels which supply the gland divided and clamped early, in order to avoid constant repetition of this portion of the technic. Bleeding points are to be secured at once; if the clamp forceps become so numerous as to be in the way, the vessels are to be ligated with catgut before completion of the operation. Hot towels applied for a few seconds will arrest the parenchymatous oozing. Complete hemostasis must be assured before the wound is closed.

Strictly aseptic conditions obviate the necessity for drainage-tubes. Copious gauze dressings are to be applied, covered by sterilized cotton, and held in place by a snugly fitting chest binder with hollow places cut under the arms. The arm is wrapped in sterilized cotton and bandaged. For the first few days the arm is placed over the chest and there secured by a few turns of a broad roller bandage. If all goes well, the dressings are not disturbed for a week, at the end of which time the sutures are removed.

The **prognosis after operation** will vary with the stage of the disease at which interference is undertaken. Death resulting from the operation itself is rare in ordinary uncomplicated cases. Before the introduction of aseptic methods the mortality was 25 per cent. Healing takes place in about fourteen days. **Recurrence** of the disease is to be expected in late cases within the first three months. The immunity from regional recurrence, or the appearance of the disease in remote parts of the body will be in direct proportion to the advances made by the disease at the time of the operation, and the completeness of the latter. Prompt recurrence may follow an incomplete operation, even when undertaken in the very earliest stages, while a complete operation may afford comparative or complete immunity when the disease is well advanced. In a recurrence the lymphatic glands are usually involved in advance of the cicatrix. Next in frequency the skin is attacked in the shape of scattered lenticular indurations. These should be promptly removed. Keloid development in the cicatrix, or at the site of suture punctures, is to be looked on with suspicion. If a year elapses without recurrence, the prognosis is thereafter favorable.

The movements of the arm are generally more or less interfered with at first, particularly that of abduction. If this interference is due to shortening of the cicatrix at the site of the incision which crosses the front of the axilla, a plastic operation may be indicated. Usually, however, this part of the incision can be

curved sufficiently in an upward direction to avoid this sequel. Early and persistent passive and active movements will usually lead to restoration of function in time. All tendencies toward recurrence should be promptly met by further operations, though the prognosis is graver under these circumstances. The average duration of life after operation, in cases in which recurrence takes place, is thirty-four months, a distinct gain of at least a year over cases which are permitted to pursue their natural course. These figures are taken from the combined statistics of Winiwarter, Fischer, and Esmarch. They were compiled by these authors before the introduction of the more radical procedures now employed. While it is true that slightly greater risks are taken with the latter, more benefit in the way of greater immunity from recurrence is derived in cases that recover.

In cases of inoperable carcinoma of the breast the treatment consists of efforts to restrict the septic processes by antiseptic applications, and possibly of the removal of broken-down portions by the sharp spoon. Opium, adminis-

Fig. 393.—Line of Incision for the Removal of Nonmalignant Tumor of the Inferior Quadrant of the Breast.

tered both internally and locally (aqueous extract of opium, 1 part, simple ointment, 20 parts), is to be used to allay pain. The application of styptics may be necessary to arrest hemorrhage.

Nonmalignant growths may be isolated and removed as elsewhere, needless sacrifice of mammary tissue and mutilation being avoided. In cases of fibromas which, as a rule, are situated on the outlying portion of the breast, the skin incision should be made in the sulcus between the lower margin of the breast and the skin of the chest wall, the parts lifted, and the tumor removed from that direction (Fig. 393). The precise location of this incision will necessarily vary with the location of the tumor.

THE BONY CHEST WALLS

Fractures of the Ribs.—Fractures of the ribs are very rarely seen in children, owing to the great elasticity of the chest walls. Later in life the bony

portions of the ribs become more brittle, and the costal cartilages also lose their elasticity by partial ossification. The false ribs are much less liable to fracture than the true ribs, owing to their cartilaginous connections, until late in life, when the latter undergo calcification and give way upon the application of greater force.

The repair of fractures involving the cartilages takes place as follows: The perichondrium furnishes a ring of bone which surrounds in a ferulelike manner the ends of the fragments. The fractured surfaces do not unite.

According to Gurlt, fractures of the ribs represent 17 per cent of all the fractures in the body. The form of fracture varies with the vulnerating force. Splintered fractures result from direct force, such as that inflicted by small missiles, while transverse fractures follow indirect force, such as forced compression of the chest in an anteroposterior direction, when several ribs may be broken simultaneously; these usually give way in the axillary line. The eleventh and twelfth ribs are rarely broken, on account of their loose connections, and the first rib escapes because of its short arch and broad transverse section. The remaining ribs (second to eighth) suffer the most frequently. The ribs on one side give way only with the lateral application of the force. When this is applied in an anteroposterior direction so as to force the sternum toward the spinal column the ribs on both sides of the chest may yield. The fragments may be displaced inward, rarely outward. Usually, however, owing to the elasticity of the chest wall, the fragments resume their normal position.

Incomplete fracture is rather commonly observed, the inner lamella being the portion bent, while the external lamella is broken. This may occur in young and middle-aged persons from elasticity of the chest walls, and in the aged from senile atrophy.

Dislocations of the costal cartilages sometimes occur after the application of comparatively slight force, on account of the arrangement of the articulations of these with the ribs, this amounting in many instances to a simple cleft surrounded by a strip of synovial membrane.

Complications.—Compound fractures are rare. In gunshot fractures, where these are penetrating or perforating, the skin injury as well as the fracture is unimportant compared with the damage done to the pleura, lung, etc. Severe contusions, or even lacerations of the lung substance may occur in the young, without fracture of the rib, the rupture of small capillaries giving rise to hemorrhage in the alveoli and small bronchi. According to König, this injury is more likely to occur if the glottis is closed when the force is applied to the chest wall. In laceration of the lung by fragments of a broken rib these are forced through both layers of the pleura. Here hemorrhage may occur into the cavity of the pleura (hemothorax) and into the alveoli and smaller bronchial tubes as well. It is removed from the latter situation by coughing. Its presence in the pleural cavity will be announced by a progressively ascending line of dullness. During expiration air is forced from the alveoli and bronchial tubes into the pleural cavity (pneumothorax); a highly tympanitic percussion note is present above the area of dullness. As the cavity of the pleura is filled with air and blood, the lung is compressed and the hemorrhage is arrested. Air that has passed along the pulmonary tract is not so likely to be followed by suppuration of the contents of the pleural cavity as that which enters through a wound in the chest wall. In the former instance the air is more or less freed

from irritating matters in its passage. The blood in the pleural cavity is generally absorbed readily; the wound in the lung heals usually by first intention, precisely as an aseptic wound of the external skin does when its edges are held in close apposition.

If the dyspnea becomes urgent, the contents of the pleural cavity may be removed by means of the aspirator. This should be delayed sufficiently long to permit perfect hemostasis at the site of the wound of the lung.

The **intercostal arteries** may be injured in cases of fracture of the rib, but the hemorrhage from this source is not, as a rule, serious. The **long thoracic** artery may be injured by a fracture of the rib and may require ligation. The internal mammary is more liable to be injured by stab wounds.

Emphysema of the connective tissue occasionally occurs when fracture of a rib and injury of the lung occur simultaneously, the pleural cavity being first filled with air, which subsequently finds its way into the loose connective tissue around the ribs, finally reaching the subcutaneous connective tissue. The accumulation in the pleural cavity, by compressing the lung, usually arrests quite promptly the escape of air, except in cases in which this is prevented by adhesions between the costal and the pulmonary surface of the pleura. Unless arrested the emphysema may reach the neck and head, and finally invade the entire subcutaneous connective tissue of the body and the connective tissue of the lungs and mediastinal space, death taking place from mechanic obstruction of the circulation and dyspnea.

Diagnosis.—Displacement of fragments is comparatively rare. Localized pain is a constant symptom. Cough and bloody expectoration may occur in contusion of the lung with or without fracture of the ribs. Palpation may disclose crepitation, but this sign is more frequently obtained by auscultation. Tenderness at the injured point may be elicited by pressure on the sternum. Deep inspiration usually increases the pain, though this is not always the case. When the pleura is injured, pleuritic friction sounds may be heard on auscultation. This may occur in only partial fracture, the inner surface of the rib giving way, while the outer surface remains intact.

Treatment.—Simple fracture of the ribs is to be treated by opiates to relieve the pain, and by strapping the corresponding half of the chest by means of adhesive plaster. Marked outward displacement of the fragments is to be corrected by pressure from without. Permanent inward displacement is rare; it may be corrected by passing a sharp hook behind the fragments and making traction. If suppurative changes take place in the contents of the pleural cavity (**pyothorax,** or **traumatic empyema**), free incision, with, perhaps, resection of a rib to facilitate draining, should be performed. Compression of the chest wall by means of an elastic bandage is useful in cases of slight emphysema. Punctures and incisions are admissible only when a slight area of emphysema exists.

Caries of the Ribs.—A number of affections were formerly included under this name. At the present time these are classified as (1) granular myelitis of tuberculous origin; (2) traumatic suppurative periostitis occurring in connection with compound fractures (gunshot injuries, etc.); (3) suppurative periostitis from phlegmonous inflammation of the soft parts of the chest wall; (4) syphilitic disease of the ribs; (5) typhoid infection of the ribs.

Granular Myelitis.—Contrary to the usual rule governing this affection,

tuberculous inflammation of the bone in this region is less frequently observed in children than in adults. It may appear even in advanced age. A cold abscess gradually develops, sometimes behind the mamma; the resulting fluctuating tumor may resemble cystic sarcoma of that organ. In other cases it passes in the direction of the pleura (**subcostal abscess**) and may be mistaken for empyema. It may invade the pleural cavity, in which case there may be caries of the rib, complicated with suppurative pleuritis.

The favorite seat of this affection is the lateral aspect of the chest wall, though the posterior and anterior portions may be attacked. The middle ribs are most frequently affected. **Granular perichondritis** of the costal cartilages leading to extensive destruction is sometimes observed. It occurs more frequently in children than in adults.

Suppurative periostitis may follow infection of wounds of the ribs and soft parts, and may result as well from phlegmonous inflammation of nontraumatic origin. The probe may detect bare bone when fistulous openings exist. The inflammation is usually only superficial and rapidly disappears after free incision, scraping of the rib with the sharp spoon, and antiseptic treatment.

Syphilitic disease of the ribs is sometimes observed. A gumma develops first. This softens and breaks down. It is difficult, in many cases, to differentiate at this stage between this condition and true caries. The history of the case must be taken into account, and other manifestations of syphilis sought for. Antisyphilitic measures may here be employed for both diagnostic and therapeutic purposes.

Typhoid infection of the ribs has been observed. The resulting lesion may assume the characters of osteitis and periosteitis, or osteomyelitis.

Treatment of Caries of the Ribs.—Prompt resection of the affected bone is indicated, not only with the hope of preventing general tuberculous infection, but in order to avoid the development of suppurative pleuritis. Granular perichondritis is best treated by exposing the affected area and gouging away the diseased cartilage. Healing by organization of a blood-clot under a dressing of oiled silk or rubber tissue (Schede) should be obtained, if possible. Healing by granulation is very tedious and frequently fails altogether, the diseased condition constantly extending, in spite of every effort.

Abscess of the chest walls originating in perforation of a suppurating cavity of the lung is sometimes observed. It is most frequently situated on the upper portion of the anterior surface of the thorax, usually at the first or second intercostal space. Adhesions generally occur before perforation takes place; the fistulous opening leads directly into the lung cavity. As the latter usually communicates with a bronchial tube, air may escape with the pus.

Billroth has described a peculiar suppurative process developing between the costal pleura and the bony chest wall (**suppurative peripleuritis**). Its origin is unknown and it is very likely to be confounded with empyema.

Neuralgia of the intercostal nerves belongs to the domain of general medicine. Nussbaum, however, once cured an intractable case of this kind by nerve stretching.

Tumors of the Ribs and Thoracic Region.—The costal cartilages are almost absolutely exempt from neoplasms.

Chondroma of the Ribs.—This is of frequent occurrence in otherwise

healthy persons. It is observed between the twentieth and the fortieth year. It springs from the bony and not from the cartilaginous portions of the ribs, is of slow growth and painless. Early successive invasion of more than one rib is the rule. The direction of the growth is generally outward and rarely toward the pleural surface. In larger growths the pressure on the skin and friction of the clothing may lead to ulceration, and death may result from breaking down of the tumor and consequent septicemia. Myxomatous degeneration may also occur and even transition to sarcoma take place (C. Hueter). Secondary nodules are liable to occur in the lungs or other internal organs, these having an embolic origin.

In view of these unfavorable tendencies in advanced chondroma the treatment should consist in early extirpation. Owing to the absence of pain as a symptom, surgical aid is not sought, as a rule, until the growth has attained a large size. In early operations the growth can be removed without opening the pleural cavity. Late interference, when undertaken at all, necessitates most desperate operative attempts.

Sarcoma.—This attacks the ribs much more rarely than chondroma. **Angiosarcoma** is the usual variety. It may occur late in life, in which case operation is scarcely justifiable. When the heads or necks of the ribs are attacked, the disease may invade the intervertebral foramina and compress the cord.

Carcinoma.—This is found only as a secondary growth in cases of carcinoma of the mamma.

THE STERNUM

Fracture.—Splintered fractures may occur in gunshot injuries or from other projectiles. Transverse fracture may follow the application of great force, the fragments becoming considerably displaced. In this class of injuries the manubrium is held securely in position by its attachments to the first rib, while the body of the sternum is displaced. This separation of the body of the sternum from the manubrium has been called a dislocation; this name, however, is incorrectly applied. The injury partakes of the character of a diastasis. The same may be said of separation of the ensiform appendix. Fracture of the sternum may occur in connection with dislocation of the upper dorsal vertebrae.

The **treatment** consists in elevating the depressed portion by manipulation with the fingers. This failing, it may be lifted into position by means of a strong hook. Serious functional results are not common even if the displacement is not corrected.

Dangerous traumatic suppuration following gunshot wounds may occur behind the sternum and invade the anterior mediastinum (**anterior mediastinitis**). The suppurative process may extend to the pleura and pericardium. The **treatment** of anterior mediastinitis, both when it results from the cause just mentioned and when it arises from suppurative processes originating in the lateral cervical region and extending beneath the sternothyroid muscles into the anterior mediastinal space, is **trephining the sternum.** The operation, however, is not performed with a trephine but with a chisel.

Syphilitic caries of the sternum is relatively frequent. **Tuberculous caries** is not rare and occurs by preference at the manubrium and upper

portion of the body of the sternum. Thorough division of all fistulous tracts, scraping away all diseased tissue with the sharp spoon, trimming away the infected lining of the sinuses, and thorough antisepsis, will prevent septic conditions in the anterior mediastinum and may result in cure. Typic resection of the diseased portion of the sternum has been successfully performed in recent times, owing to the advantages of asepsis and antisepsis. In syphilitic cases antisyphilitic treatment should supplement the operative procedure.

Sarcoma of the sternum is observed. It develops as true sarcoma of the bone or originates in the connective tissue of the anterior mediastinal space. A large soft tumor is formed, which gradually destroys the sternum and finally invades the skin. Destruction of the upper portion of the sternum also attends the development of aneurism of the ascending portion of the arch of the aorta. **Chondroma** of the sternum is comparatively rare. **Resection of the entire sternum** has been successfully performed for osteoid chondroma (König). The justifiability of operative interference in sarcoma of the sternum must rest on the possibilities of removal of the entire disease.

Congenital fissure of the sternum is mentioned as a curiosity. The physiologic action of the heart can usually be studied through the skin which fills in the hiatus.

EFFUSIONS INTO THE PLEURAL CAVITY AND THEIR SURGICAL TREATMENT

Effusions into the pleural cavity may result from the lodgment of foreign bodies, from injury to the pleural membrane by a fractured rib, from the presence of malignant growths, from circulatory disturbances (hydrothorax), and from simple pleuritis.

Hydrothorax is a simple noninflammatory watery effusion into the pleural cavity and is due to circulatory disturbances following diseases of the heart and kidney, and to changes in the blood itself. The accumulation usually takes place in both sides of the chest and may threaten life by suffocation. It may be removed by aspiration.

In simple **pleuritis with effusion,** if two-thirds or more of the cavity of the pleura is occupied by the serous exudation, the pressure of the accumulated fluid will be such as to prevent the absorbent vessels from disposing of the fluid. Here a portion or all of the fluid may be withdrawn by simple aspiration.

Septic and **tuberculous** inflammation of the pleura may follow similar affections of the pulmonary tissues.

Empyema.—A suppurative pleuritis is known as empyema. Staphylococci and streptococci are usually found in the pus. Ordinary catarrhal bronchitis may furnish the microorganisms which, through involvement of some of the alveoli, may lead to infection of the pleura and consequent suppurative pleuritis. A serous effusion from idiopathic (primary) pleuritis may become infected by the pneuococcums of a coincident pneumonia. Or, bacterial infection may occur in a carelessly performed exploratory puncture, and empyema result. **Gangrene of the pleura** has been observed in connection with general pyemia.

Two or more separate cavities may be present at the same time (**encysted pleuritic effusion** and **encysted empyema**). The fluid in one cavity may remain serous and be absorbed, while that in the other may become infected and

undergo suppuration. These cavities may be separated from each other by adhesions between the visceral and the costal reflections of the pleura.

The **gonococcus** of Neisser may diffuse itself and give rise to inflammatory conditions in the pleural cavity, as well as in other serous cavities (Mazza). It is probable that the **Bacterium coli commune,** the migrating character of which has been established beyond doubt (Wyss, Tavel), is occasionally the infecting agent.

The occurrence of a perforating gastric ulcer in the upper and posterior stomach wall may give rise to **subphrenic abscess,** the pus making its way along the muscular planes of the diaphragm, finally emptying into the pleural cavity and there exciting a septic pleuritis.

The **prognosis** in simple pleuritis with effusion is always favorable. Aseptic aspiration, even if only a portion of the fluid is removed, is always followed by recovery. In septic pleuritis recovery usually follows appropriate surgical treatment. In cases in which the effusion is of tuberculous or cancerous origin, and in pyemic gangrene of the pleura, the prognosis is most grave.

Delay in operative interference in septic and suppurative pleuritis may lead to rupture into a bronchus and evacuation of the cavity by coughing. Cure occasionally takes place in this manner. This method of evacuation is fraught with danger, however, since the discharge may be so profuse as literally to drown the patient in his own pus.

The persistence of a seropurulent fluid in the pleural cavity is known as **chronic empyema.** There is progressive thickening of the pleura due to the deposition of successive layers of fibrin, compression of the lung until the latter occupies but an extremely small portion of the corresponding half of the thoracic cavity, and the formation of dense adhesions which imprison the lung and prevent its expansion.

The Surgical Treatment of Pleuritic Effusions.—If, after a reasonable trial of salines and hydragog cathartics, a simple serous effusion is not removed, operative measures must be resorted to. When the effusion is purulent from the commencement, the employment of such measures is but a waste of time; the longer the operative interference is postponed, the greater the difficulties encountered, owing to the thickening of the pleura and the formation of adhesions in securing expansion of the lung after evacuation of the fluid.

Simple Puncture and Aspiration.—This is indicated as follows: (1) In cases of rapid accumulation in which great dyspnea arises from compression of the lung, before compensatory expansion of the other lung can take place. (2) In cases of slow accumulation in which absorption is prevented by pressure, two-thirds or more of the corresponding half of the thoracic cavity being occupied by the fluid. If the serous effusion is due to the presence of tuberculous disease, the improvement will be only temporary. (4) In doubtful cases for purposes of exploration.

When the effusion is large, the pleural cavity can be punctured at different places. In encysted or **encapsulated** effusions, the fluid developing between different layers of adhesions, or where the cavity of the pleura is divided into several compartments by adhesions between the interior of the chest wall and the pulmonary pleura at different points, repeated punctures may be necessary

before locating the fluid. The latter may also occupy several separate spaces (multiple encapsulation). In ordinary cases the puncture is usually made in the lateral thoracic region on the axillary line, and in either the fifth, the sixth, or the seventh intercostal space. A puncture on a line with the angle of the scapula is safe on either side.

A slight incision in the skin may be made if the operator so fancies. If this is done, cocain anesthesia should be employed. Usually, in large effusions, the intercostal spaces are prominent and the puncture is easily made. The point of the left index-finger is pressed firmly in the intercostal space to steady the trocar and prevent it from gliding off on the surface of the rib as the patient makes a quick respiratory movement at the contact of the instrument. The latter should hug the upper edge of a rib to avoid the intercostal artery. When, from any reason, it becomes necessary to puncture in the lower intercostal spaces, the point of the trocar must be directed obliquely upward to avoid injury to the diaphragm, and to the liver on the right and the spleen on the left side.

During the operation of tapping, the fluid should be permitted to escape only slowly, in order to avoid circulatory disturbances in the heart and large vessels, the formation of coagula on the walls of the latter, and the loosening and subsequent passage of these into the pulmonary arteries. These precautions are doubly necessary in left-sided effusions, the heart being displaced to the right (dextrocardia). Hence, these disturbances are more likely to occur if the heart is suddenly permitted to resume its normal position. The flow should be interrupted from time to time by compressing the tube or by placing the finger over the open end of the cannula.

When the aspirating trocar is used, air is effectually prevented from entering and the flow is continuous, the lung expanding to replace the evacuated fluid. Whether the tapping is performed with an ordinary trocar or with an aspirating apparatus the lumen of the instrument may become obstructed by fibrinous material and require clearing by means of a blunt probe or a wire.

In pleuritic effusions complicating well-marked tuberculous disease of the lungs aspiration should be delayed until demanded by purulent changes in the fluid, as shown by exploratory puncture, considerable displacement of the heart, and marked increase in the dyspnea.

Incision (Thoracotomy).— This is indicated (1) in cases in which there are constantly recurring effusions that are nontuberculous and nonmalignant; (2) in cases of primary septic or suppurative pleuritis and in cases of septic infection of previously existing serous effusion. It may also be resorted to in cases in which repeated tapping has failed. It is rarely employed at the present day except in children. The operation is made in the localities indicated for tapping. The skin incision is made over an interspace and the muscular tissues and serous membrane divided in turn. The fluid must not be permitted to flow away too rapidly. Where the effusion is large and recent, it is better to remove a portion of the fluid first by slow tapping, or aspiration. In effusions of long standing, as well as in "empyema of necessity," where the pus from a pyothorax has found its way beneath the thoracic muscles, this precaution is not necessary.

The incision is made about three inches in length in a longitudinal direction in the midaxillary line at the upper border of the sixth or seventh rib. Incision is usually supplemented by tube drainage. Irrigation of the chest cavity should not be employed. In recent cases of empyema in young children recov-

ery has sometimes been quite rapid under this treatment. When the lung is collapsed from compression, as well as from cicatricial contraction, the cure is tedious, from failure of obliteration of the suppurating cavity. In young subjects the obliteration sometimes takes place at the expense of the chest wall, the latter collapsing from above downward, and lateral curvature of the spinal column (**scoliosis**) results. As a further effect of this collapse of the chest

Fig. 394.—Position for Operations on the Chest Walls and on the Pleura, Lungs, etc.

wall the intercostal spaces are narrowed and the elastic drainage tube is compressed. Metal tubes are unsatisfactory, and the best result under these circumstances is obtained by resection of a portion of one or more ribs.

Resection of a Portion of Rib.— This is usually the procedure of choice in adults and is frequently necessary in children. Where considerable dyspnea is present, and the voluntary muscles of respiration are brought into play to assist in breathing, a general anesthetic should be avoided and the operation per-

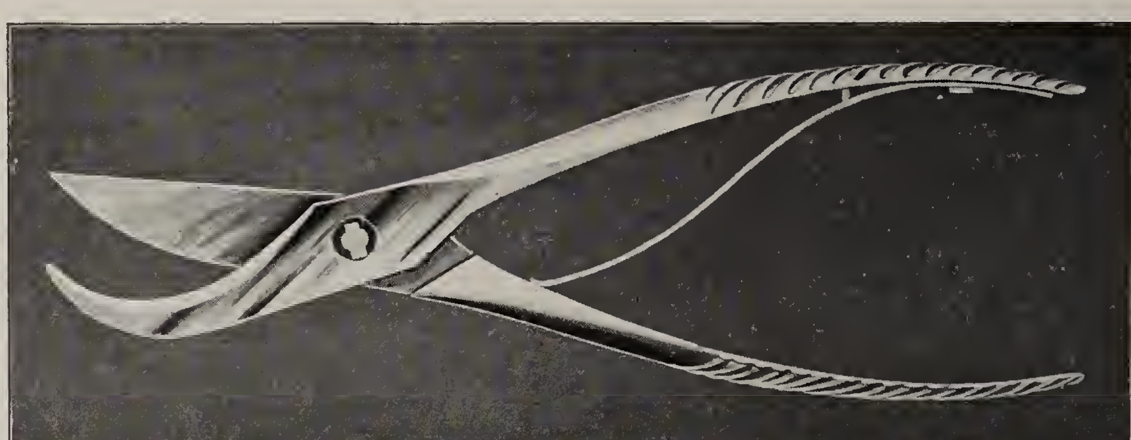


Fig. 395.—Costotome.

formed under local anesthesia (cocain). Some surgeons advise that aspiration be employed the day previous to the operation, to permit the use of a general anesthetic. The patient should be placed supine, or nearly so, in order to permit free expansion of the sound lung (Fig. 394). The incision should expose the sixth rib in the midaxillary line so as to permit the removal of an inch or more of the rib. The latter is divided by the costotome (Fig. 395) in two

places about one inch apart, and the intervening piece grasped by the bone forceps and finally freed and removed. By proceeding in this manner the investing periosteum is removed with the section of rib, and the narrowing of the opening by the rapid formation of bone prevented. The intercostal artery will require ligation at each side of the incision.

Thoracoplasty.—Plastic operations on the chest wall are employed as secondary procedures in cases of empyema in which the collapsed lung is prevented from expanding by the presence of dense adhesions and thickened pleura; and in cases in which partial expansion takes place, the rigid chest wall failing to collapse sufficiently to effect its proper approximation to the lung. It is indicated as a primary operation in old cases of empyema in which the above conditions are revealed at the outset by the resection of a portion of rib.

Estländer's operation consists of the removal of portions of the second, third, fourth, fifth, sixth, and seventh ribs. These may be reached through three transverse incisions, two ribs being removed through each incision. Or, a vertical incision or a U-shaped flap may be used. In order to prevent reproduction of the ribs, which would defeat the object of the operation, namely, the permanent collapse of the chest wall, the periosteum must be removed with the ribs. Irrigation of the cavity is usually safe in cases in which this operation is indicated. The incisions are closed with silkworm-gut and cavities are drained by a large tube. Small cavities may be packed with antiseptic gauze.

Schede's operation is designed to accomplish the same object as Estländer's, but in a more radical manner. By means of this procedure, not only the ribs with the periosteum are removed, but the thickened parietal pleura and intercostal muscles as well. The operation is to be reserved for that class of cases in which the pleura is greatly thickened, and in which the removal of portions of the ribs alone will not suffice to secure collapse of the chest wall to fill the space formerly occupied by the fluid.

The operation is performed as follows: The bony chest wall is bared by reflecting a modified U-shaped flap in an upward direction. The incision marking out this flap commences in front at the outer edge of the pectoral muscle, on a level with the fourth rib, passes downward to curve at the level of the tenth rib, is carried thence to the midaxillary line, from which point it again curves and passes to the posterior scapular line, thence continuing upward along a line midway between the vertebral border of the scapula and the spinous processes to the level of the second rib (Fig. 396). The arm is elevated so as to reach the tubercles of the upper ribs that are to be removed. The incision is carried down to the ribs throughout its entire length, the soft parts turned upward, the scapula displaced and the ribs successively divided, first along the costochondral articulations and then at the tubercles, and this portion of the chest wall removed in one mass, including the pleura and intercostal muscles. The flap is then replaced with its raw surface resting against the visceral layer of the pleura and sutured with silkworm-gut. Drainage is provided for by one or more drainage-tubes.

Pleurotomy with detachment of the visceral layer of the diseased pleura (pulmonary decortication, Délorme, 1894) is employed for the purpose of releasing the lung from its environment of thickened and adherent pulmonary pleura. An incision is made through the visceral pleura and the opening thus made extended by merely separating the investment

of the lung or by both separating and cutting away the pleura. Good results have been obtained by this procedure, even in cases in which the lung failed to expand at first.

Fig. 396.—Lines of Incision for Schede's Operation of Thoracoplasty.

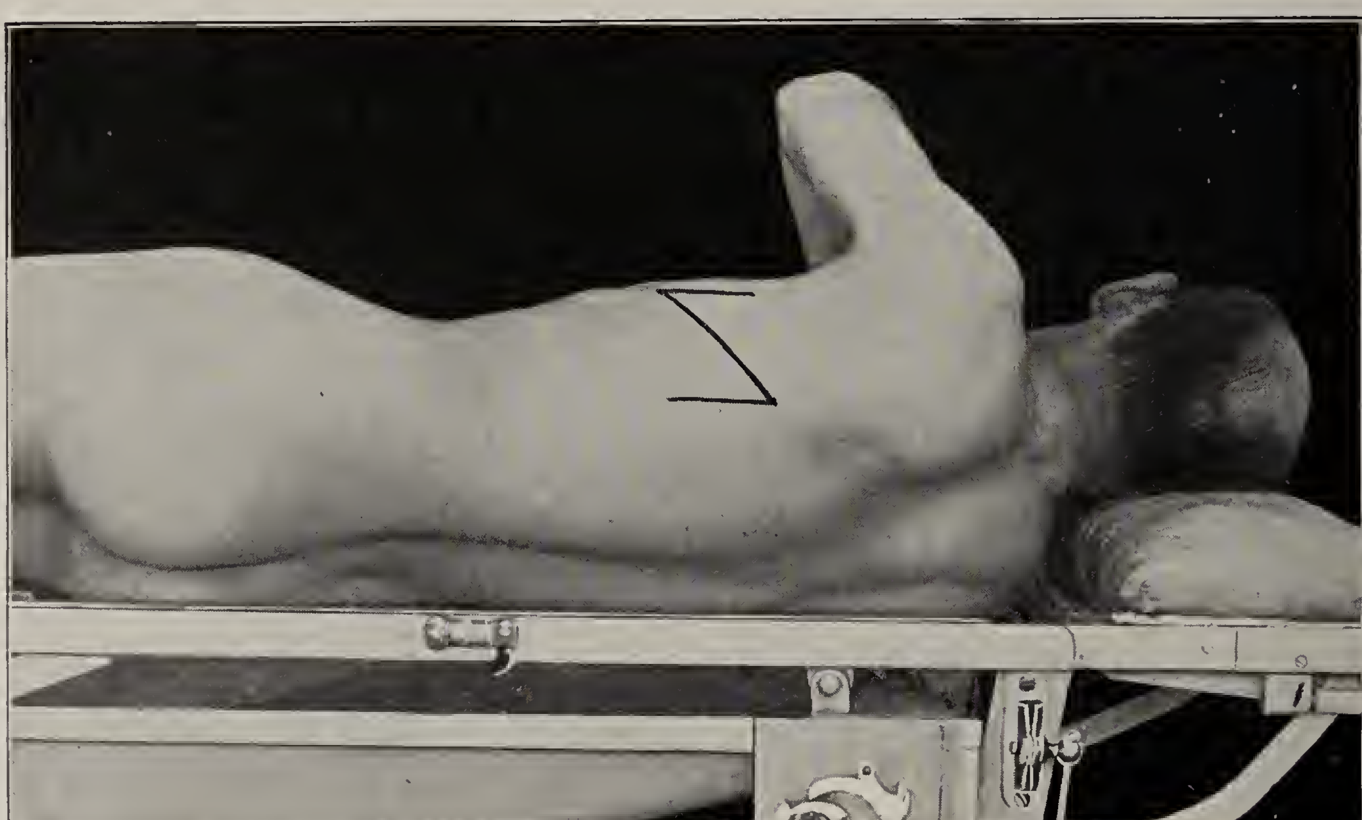


Fig. 397.—The Author's Lines of Incision for Resecting the Ribs in Pleurectomy.

Total pleurectomy was first performed on October 27, 1893, by the author in a case of chronic empyema of two years' standing.* A portion of the

* "Medical Record," December 30, 1893.

bony chest wall was resected and the entire pleura dissected away as a dense fibrous cicatricial mass. The patient, a rather delicate woman, completely and permanently recovered.

The operation is indicated when the lung is bound down with dense adhesions so that expansion is impossible, and where Estländer's operation has failed. It may even replace the latter. It is to be preferred to the extensive resection of the ribs and the partial pleurectomy of Schede's operation. The procedure attacks the two causes of failure of cure of empyema, namely, inability of the lung to expand, and the presence of an infected mass of fibrous cicatricial tissue replacing the pleura. It should not be employed in cases demonstrably tuberculous in character.

If the case has not been previously operated on, an opening is made in the sixth intercostal space and the interior of the chest explored with the finger. If the indications for total pleurectomy present themselves, the incision should be extended as above indicated.

The operation is performed as follows: If a sinus is present from a previous operation for drainage, this is lengthened in either direction along the corresponding intercostal space, until the latter is opened to the extent of from 8 to 9 inches. A vertical incision is made from the posterior termination of this incision in a downward direction, and another from its anterior extremity in an upward direction (Fig. 397). The two triangular shaped flaps thus marked out are reflected, the first downward and backward, and the second upward and forward, to an extent sufficient to gain access to four ribs, and the latter are resected for about eight inches. The removal of the pleura is effected by blunt dissection, the "peeling" process proceeding so as to remove the visceral layer last. An incision across the latter will permit removal of the pleural membrane at this point without injury to the lung. The latter expands somewhat as it is released, in spite of the large opening in the chest wall, and usually fills a considerable portion of the chest cavity at the completion of the operation. The flaps are replaced and sutured, provision being made for drainage. If the cavity is thoroughly cleansed before the operation, irrigation is omitted.

Separation of the Ribs from the Sternum.—This has been suggested (Jaboulay) as a substitute for Estländer's procedure, or as supplementary to it, where the greatest diameter of the suppurating cavity is vertically placed. The first seven ribs are separated. In some cases it may be necessary to resect portions of rib as well.

THE LUNGS

Abscess of the Lung.—This may follow ordinary pneumonia, when it is usually single; it is more likely, however, to follow aspiration pneumonia, in which case there are usually multiple abscesses. It may result from a subdiaphragmatic abscess following appendicitis, the infection propagating along the lymph-channels of the diaphragm. It may occur in the course of cancer of the esophagus or follow a wound of the lung, with or without lodgment of a foreign body. Infectious emboli may lodge in the vessels of the lung tissue, causing multiple abscesses (metastatic abscess). Pneumococci, streptococci, staphylococci, or colon bacilli may be present.

The expectoration is very offensive, and in it fragments of lung tissue may

be detected by microscopic examination. It is coughed up in mouthfuls during paroxysms of coughing occurring several hours apart. There is dullness on percussion if the abscess cavity is large and full of pus. The physical signs of a cavity are present as the abscess is emptied of pus and air enters. Small pyemic or metastatic cavities may be overlooked.

The **treatment** consists in resection of a portion of rib, the cavity being located with the aspirating needle, and the needle, which is left in for the purpose, followed as a guide, the lung over the cavity incised with the thermo-cautery, and a rubber drainage-tube introduced. If the two layers of pleura are not adherent over the abscess cavity, and the latter can be temporarily emptied by aspiration, the opening in the chest wall may be tamponed for two or three days until adhesions have formed. If the pus cannot be aspirated and the symptoms are urgent, the place where the opening is to be made may be walled off by iodoform gauze and the operation proceeded with. The operation should be performed under chloroform or local anesthesia. If the former is employed, its administration may be suspended as soon as the lung tissue is reached, as the latter is quite insensitive.

Gangrene of the Lung.—The invasion of the lung tissue by pyogenic microorganisms is sometimes followed by complete devitalization of the former and consequent gangrene. The invasion may result from injuries or operations about the mouth (cancer of the tongue, etc.); from wounds of the lung or the lodgment of foreign bodies in the lung, embolism of the pulmonary artery, pneumonia or bronchitis, and tuberculous or malignant disease of the lung. The gangrene may be diffused or circumscribed and may occur in single or multiple areas. The lung tissue putrefies, softens, and is coughed up, a gangrenous cavity remaining.

Symptoms.—Expectoration is infrequent and sometimes absent; the expectorated matter is usually large in quantity and horribly offensive. The odor of the breath is repulsively foul. The patient lies on the diseased side. The physical signs may be either those of consolidation or those of a cavity. Pulmonary hemorrhage may occur. Spontaneous cure may, though rarely, take place, the cavity becoming surrounded by adhesions and obliterated by granulations. Death may occur in a few days, or the patient may live for several weeks and finally succumb from exhaustion.

Treatment.—An attempt to reach the gangrenous area and effect drainage should be made, as in pulmonary abscess. In order to prevent pneumothorax the operation may be performed in two stages, as in abscess of the lung.

Operations on Cavities in the Lung.—The first recorded attempt to reach a cavity in the lung was made in 1664 (Willis). Several attempts were made by Barry (1726). The first to employ antiseptic applications was Mosler (1873). E. Bull collected the statistics of 26 cases of operations on the lung. Of these cases, 4 were cured, 15 were improved, and in 7 the procedure was followed by no improvement whatever. In addition to these, Lauenstein operated successfully for bronchiectasis. Pyemic abscess of the lung has also been cured by operation.

The indications for **pneumotomy,** therefore, may be said to be bronchiectasic cavities, abscesses of the lung near the surface, pyemic infarcts, foreign bodies, echinococcus cysts near the surface, and single tuberculous cavities with slight outlying infection in cases in which the disease is only slowly progressive.

The operation is generally useless in tuberculous cavities, on account of the wide infection of the pulmonary tissues. Before the operation can be proceeded with, it must be determined, if possible, that adhesions exist between the seat of the lesion and the chest wall. In old abscesses these are usually present.

Where adhesions cannot be demonstrated beforehand, the introduction of an exploring needle, after incising to the pleura in an intercostal space, may give the necessary information if note is taken of the depth to which the needle passes before the appearance of pus in the exhausted barrel of the syringe; further, if it is demonstrated that the needle remains stationary during the respiratory movements, it may be taken for granted that the instrument has passed through a solid adhesion. If no adhesions are present, it is better to postpone the operation, except where urgent symptoms are present, else pneumothorax may follow the operation. After the exploratory puncture, resection of a rib is performed and the abscess or other cavity finally reached by means of the thermocautery (see Fig. 96).

Pneumectomy, or resection of the diseased area, has been successfully performed (Tuffier), but has not met with general acceptance.

Injection of nitrogen into the pleural sac for the purpose of occluding the lymph-channels, preventing hemorrhage, and effecting compression of the lung and the development of fibrous tissue in order to favor healing of the cavity, has been employed (J. B. Murphy). Every three or four weeks 120 c.c. of nitrogen gas are injected.

Resection of an adjacent portion of lung was performed by Krönlein while operating for sarcoma of the ribs. Experiments on the lower animals for resection of lung substance were carried out successfully by Schmid and others.

Tumors within the Thoracic Cavity.—**Primary Sarcoma of the Lung.**—This occurs as a large tumor, extending at first within the thoracic cavity and then forcing its way between the ribs, and finally crowding the latter outward. The soft parts of the chest finally become involved. These growths are likely to be mistaken for chrondromas, and *vice versa.*

Echinococcus of the Lung.—This may occupy a central position in the lung or attack the periphery and extend to the pleural cavity. It may also exist as an extension from the pleura or from the liver, reaching the lung by successive involvement of the diaphragm and pleura. When occurring primarily in the central portion of the lung, the first evidence of its presence is the appearance of the characteristic cysts in the sputum. When the periphery is attacked, and encapsulated pleuritis is supposed to exist, the diagnosis is made only when exploratory puncture is performed. The treatment is limited to inhalations of antiseptic vapors (turpentin in hot water) to prevent septic complications.

Intrathoracic Aneurism.—This usually commences as a cylindric enlargement of the arterial tube, afterward developing into the sacculated variety. The intercostal spaces are at first widened by the powerful impulse of the tumor; destruction of the bony chest wall follows, and finally a pulsating tumor makes its appearance. In case the arch of the aorta is involved the swelling is below the left clavicle, and in the neighborhood of the first, second, and third ribs. In aneurism of the innominate artery the tumor presents in the middle line and to the right (Fig. 398). The destruction of the bony structure is accompanied by constant gnawing pains. Life is threatened by the rupture of the

aneurismal sac. As a palliative measure it is recommended to place narrow strips of gauze over the tumor, and apply contractile collodion over these. (See Operations for the Cure of Aneurism.)

Hernia of the Lung.—This occurs at the upper opening of the thoracic cavity, the lung being forced into the supraclavicular fossa by deep expiration, where its presence can be demonstrated by percussion. It has also been observed projecting in the upper intercostal spaces and in front, as a result of congenital absence of the costal cartilages. A traumatic form has been described following extensive destruction of the chest wall, the resulting cicatrix yielding under

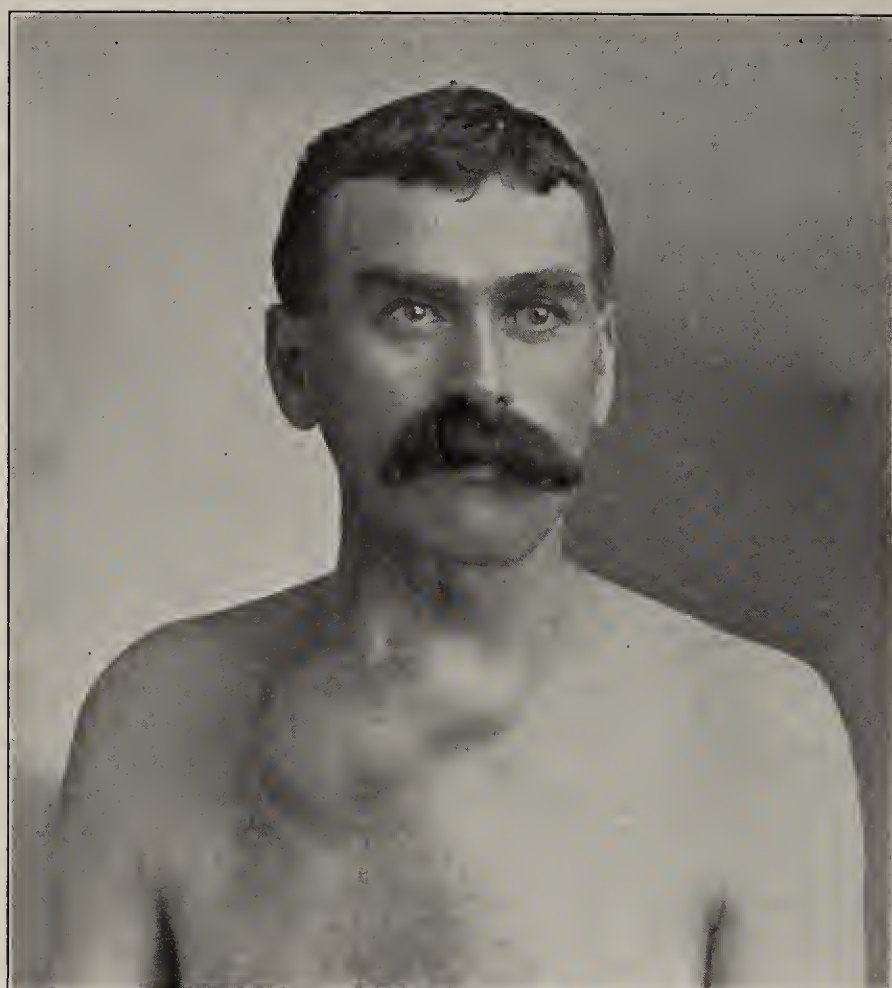


Fig. 398.—Aneurism of the Innominate Artery (Dr. T. R. Maxfield's Case).

intrathoracic pressure. The **diagnosis** is made by the movements of the tumor during the respiratory acts and by auscultation and percussion. The **treatment** is only palliative, consisting of the application of properly regulated pressure.

THE HEART AND PERICARDIUM

Wounds of the Heart and Pericardium.—These generally prove immediately fatal. In exceptional cases life has been prolonged for a short time, and in rare instances recovery has taken place. Of the latter, 72 cases are recorded, in which the diagnosis was subsequently confirmed by autopsy. In 12 cases of foreign bodies in the heart in which recovery occurred, after varying periods of time autopsy revealed needles in 6 cases, bullets in 5, and a thorn in one case (Hueter). Syncope usually occurs, and this has a beneficial effect, inasmuch as it favors thrombosis and arrest of hemorrhage. Oblique punctured wounds of the ventricles are less rapidly fatal than wounds of the

auricles. The comparatively thin muscular walls of the latter do not favor closure of the opening.

Treatment.—Heretofore this has been limited to closure of the external wound. In view of the fact that death usually takes place from inhibition of the heart's action due to overfilling of the pericardium with effused blood, the attempt may be made to reach the cavity of the latter, either through the wound or by resection of one or more ribs (**pericardiotomy**) and to relieve the pressure (E. Roser). Search for foreign bodies and removal of them, arrest of hemorrhage and suture of the wound in the ventricle will naturally follow. **Venesection** has been proposed (Stromeyer), and was successfully carried out by Rose in a case in which extreme cyanosis and marked increase in the area of heart dullness were present after a stab wound of the heart.

Dropsy of the Pericardium.— This occurs as a result of serous pericarditis and may demand surgical interference to ward off impending death from paralysis of the heart. Puncture and aspiration (**paracentesis of the pericardium,** B. F. Westbrook) are not difficult of performance. The area of dullness and the bulging intercostal spaces form a ready guide for the introduction of the trocar or needle. The heart is usually crowded well back and out of the way of injury. The upper edge of the sixth costal cartilage near the left lateral edge of the sternum is the most favorable place for the puncture. The operation is practically without danger if aseptic precautions are observed and entrance of air avoided.

Pyopericardium.— This results from suppurative pericarditis. **Pericardiotomy, followed by drainage,** is indicated. The incision is made near the left edge of the sternum, between the fourth and the fifth costal cartilage. **Pneumopyopericardium** constitutes an urgent indication for the prompt performance of incision and antiseptic treatment. The condition is recognized by a tympanitic percussion note, and succussion sounds occurring synchronously with the heart's action. It may result from the development of gases from putrefaction in suppurative pericarditis, from the breaking down of pulmonary tissue in communication with the pericardium, from extension from the pleural cavity, from communication with a bronchus, or from simultaneous gunshot wounds of the lung and pericardium.

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